

Environmental Assessment

**HOT FUEL EXAMINATION
FACILITY/SOUTH**

Public Reading Room



U.S. Department of Energy



Department of Energy

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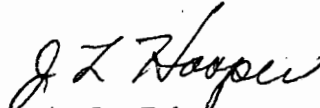
Dear Sir:

SUBJECT: ENVIRONMENTAL ASSESSMENT (EA) AND FINDING OF NO SIGNIFICANT IMPACT
(FONSI) FOR THE HOT FUEL EXAMINATION FACILITY/SOUTH (HFEF/S)

The HFEF/S is located at the Argonne National Laboratory-West (ANL-W) site at the Idaho National Engineering Laboratory (INEL) near Idaho Falls, Idaho. The HFEF/S is a Government-owned facility operated by the University of Chicago under contract with the U. S. Department of Energy (DOE). The HFEF/S, initially activated in 1963, is currently undergoing modification.

The DOE, based on the analyses in the EA, has determined that the modifications and operation of the modified HFEF/S will not have a significant effect on the quality of the human environment within the meaning of the National Environmental Policy Act (NEPA). In accordance with paragraph 1506.6(b)(3) of the Council on Environmental Quality NEPA Regulations, enclosed for your information are copies of the subject EA and FONSI. Any questions or requests for additional copies of the EA and FONSI should be addressed to the appropriate DOE contact listed in the FONSI.

Sincerely,


A. L. Taboas
Area Manager

Enclosures:
As Stated

Environmental Assessment

**HOT FUEL EXAMINATION
FACILITY/SOUTH**

May 1990

**Prepared by the
U.S. Department of Energy**

ENVIRONMENTAL ASSESSMENT FOR HFEF/S MODIFICATIONS FOR EXPERIMENTAL FUEL CYCLE DEVELOPMENT

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LIST OF ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
ALARA	As Low As Reasonably Achievable
ANL-W	Argonne National Laboratory-West
CAM	Continuous Airflow Monitors
CFA	Central Facilities Area
CFR	Code of Federal Regulation
CR	Divilian Repository
DBA	Design Basis Accident
DOE-ID	Idaho Operations Office of the Department of Energy
EBR-II	Experimental Breeder Reactor-II
EFL	Experimental Fuels Laboratory at ANL-W
EP	Extraction Process
EPA	Environmental Protection Agency
ESRP	Eastern Snake River Plain
F/A	Fuel Assembly (EBR-II)
FCF	Fuel Cycle Facility
FMF	Fuel Manufacturing Facility
FPR	Fuel Processing and Restoration
HEPA	High Efficiency Particulate Air
HFEF/N	Hot Fuel Examination Facility/North at ANL-W
HFEF/S	Hot Fuel Examination Facility/South
HRF	Hot Repair Facility
HVAC	Heating, Ventilation, Air Conditioning
HWSF	Hazardous Waste Storage Facility
IBC	Inter-building Cask
ICPP	Idaho Chemical Processing Plant
ICRP	International Committee on Radiological Protection
IFR	Integral Fast Reactor
ILTSF	Intermediate Level Transuranic Storage Facility
INEL	Idaho National Engineering Laboratory
NERP	National Environmental Research Park
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NRC	Nuclear Regulatory Commission
PSD	Prevention of Significant (Air Quality) Deterioration
PUREX	Plutonium Uranium Recovery by Extraction
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act of 1976
RLWTF	Radioactive Liquid Waste Treatment Facility
RMWSF	Radioactive Mixed Waste Storage Facility at INEL
RSWF	Radioactive Scrap and Waste Facility
RWMC	Radioactive Waste Management Complex
SHADE	Shielded Hot Air Drum Evaporator
SPERT	Special Power Excursion Reactor Test Area
TBD	To Be Determined
TLV	Threshold Limit Value
TRU	Transuranic
TSA	Transuranic Storage Area at INEL
TSD	Treatment, Storage, or Disposal
WERF	Waste Experimental Reduction Facility
WIPP	Waste Isolation Pilot Plant

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FOREWORD

This document describes the potential environmental impacts associated with proposed modifications to the Hot Fuel Examination Facility/South (HFEF/S). The proposed action, to modify the existing HFEF/S at the Argonne National Laboratory-West (ANL-W) on the Idaho National Engineering Laboratory (INEL) in southeastern Idaho, would allow important aspects of the Integral Fast Reactor (IFR) concept, offering potential advantages in nuclear safety and economics, to be demonstrated. It would support fuel cycle experiments and would supply fresh fuel to the Experimental Breeder Reactor-II (EBR-II) at the INEL.

ENVIRONMENTAL ASSESSMENT FOR HFEF/S MODIFICATIONS
FOR EXPERIMENTAL FUEL CYCLE DEVELOPMENT

I. INTRODUCTION

A. Purpose and Scope of the Proposed Action

The proposed action is to modify the existing Hot Fuel Examination Facility/South (HFEF/S) by making appropriate safety changes and providing new process equipment. The ultimate purpose of the proposed action is to provide essentially complete fuel cycle service for the Experimental Breeder Reactor-II (EBR-II). In providing this service, HFEF/S would conduct an experimental development program for the unique metal fuel cycle that is the basis for the Integral Fast Reactor (IFR) concept. EBR-II and HFEF/S together would provide a complete integrated system test of the IFR concept. All activities would take place within modified existing facilities on the U.S. Department of Energy (DOE), Argonne National Laboratory-West (ANL-W) site on the Idaho National Engineering Laboratory (INEL) site in southeastern Idaho. Photographs of the site and the facilities as they now exist can be found in Appendix E.

The proposed action would not change the total number of fuel assemblies supplied to EBR-II, nor would it alter the number of spent fuel assemblies requiring disposition. It would change the location on the ANL-W site at which the fuel is produced, and it would reduce the transport of fresh uranium and/or plutonium. It could substantially reduce or even eliminate the transport of spent fuel to other locations for processing or indefinite storage.

For each fuel assembly recycled in the experiments proposed in HFEF/S, one less fuel assembly is required to be fabricated from fresh makeup materials in the Fuel Manufacturing Facility (FMF) and/or Experimental Fuels Laboratory (EFL), and one less fuel assembly would be shipped to the Idaho Chemical Processing Plant (ICPP) for processing. FMF and EFL are where fuel for EBR-II is currently fabricated, and ICPP is where EBR-II spent fuel has been sent for processing and recovery of unused uranium.

Demonstrating the economic and safety potential of this fuel cycle is a key element of the U.S. advanced reactor development program. Without modification of HFEF/S, only small-scale, incomplete experiments could be done, with no possibility of an integrated system test.

The proposed fuel cycle program is needed to establish the feasibility of the IFR concept, which includes proving the feasibility of a high-temperature metal fuel cycle for advanced liquid-metal cooled reactors. The IFR program is considered important to the national interest because of its potential to improve nuclear power economics and because of the inherent safety achievable through use of liquid-metal cooling and metallic fuels. Other potential benefits of this fuel cycle include natural diversion-resistance of the processed fuel because of residual inherent radioactivity.

B. Background

The proposed use of HFEF/S is not entirely new. HFEF/S was activated in 1963 with the original mission of developing an early version of the presently proposed fuel processing technology. A fuel cycle test in conjunction with EBR-II was successfully carried out during 1964-69 (Ref. I-1). During that time HFEF/S, then called the Fuel Cycle Facility (FCF), remotely processed and returned to EBR-II over 35,000 fuel elements. This is equivalent to about five EBR-II core loadings. A pyrometallurgical process was used in which the spent uranium-metal-alloy fuel was melt-refined in zirconia crucibles and injection cast to form new fuel pins. The pins were then inserted into stainless steel cladding tubes which contained a small amount of sodium to act as a thermal bond. The tubes were seal-welded to form new fuel elements that were assembled into fuel assemblies -- all by completely remote methods.

The success of this early program in conducting a fuel processing operation in support of the same EBR-II reactor, with no significant impact on the environment, is strong evidence that the proposed program, similar to the earlier one, but using advanced techniques and environmental controls, could likewise be conducted without significant environmental impact.

C. Proposed Action Compared to Present Fuel Cycle Operations

The proposed action would, if the fuel cycle development experiment to be carried out in the modified HFEF/S is successful, consolidate EBR-II fuel reprocessing and fabrication into one facility, the HFEF/S. Use of HFEF/S to provide fuel cycle services to any other reactor is not a part of the proposed action.

EBR-II, like all reactors that produce electrical power, requires periodic refueling. Fuel for this reactor is uranium-zirconium or plutonium-uranium-zirconium metal slugs [about 0.5 cm (0.2 inches) in diameter and 34 cm (13.5 inches) long] sealed inside stainless steel cladding jackets [about 91 cm (36 inches) long] to form a fuel element. Roughly 60 of these fuel elements are placed in a stainless steel duct [about 2.4 m (8 feet) long] to form a fuel assembly. About 60 such fuel assemblies are required each year.

Presently this fuel is made in two facilities at the Argonne site on the INEL. "Driver" fuel, a standard uranium-zirconium fuel that makes up about 80% of the fuel supplied to EBR-II, is made in the Fuel Manufacturing Facility (FMF). Experimental fuel, which is used in the fuel research and development (R&D) portion of the IFR program, makes up about 20% of the fuel supply, and is made in the EFL, a small glove box laboratory.

Fuel discharged from EBR-II now goes into indefinite storage (if it is experimental fuel) or in the case of driver fuel, is packaged in HFEF/S or the Hot Fuel Examination Facility/North (HFEF/N) for shipment to the ICPP. The ICPP, located 39 km (24 miles) from ANL-W, requires 18.4 km (11.5 miles) of travel over DOE access roads and 20 km (12.5 miles) of travel over U.S. Highway 20.

From the perspective of fuel fabrication, differences in the environmental impact are trivial. All EBR-II fuel is presently fabricated on the ANL-W site, as would be the case under the proposed action. Moreover, the technology of fuel fabrication would be identical to current ANL-W operations at the FMF. The proposed action shifts the operations to a different facility

(HFEF/S), with similar filtration and confinement features, located no more than a few hundred meters from the presently used facilities.

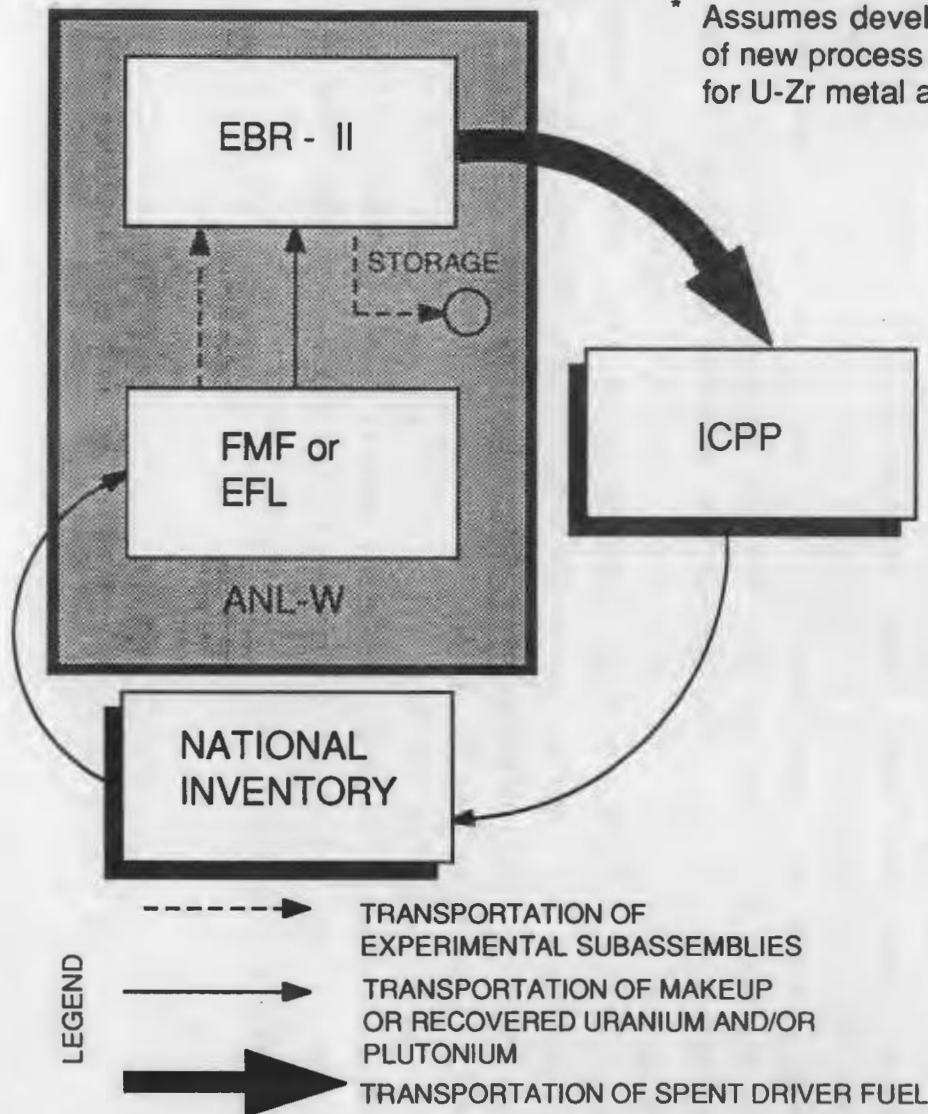
With respect to fuel processing, any driver fuel assemblies processed in EBR-II as a consequence of the proposed action would have been processed at ICPP under a No Action Alternative. Thus the effect is to shift the location from the western side of the INEL to the eastern portion. The reprocessing technology, however, is quite different (PUREX at ICPP; the IFR pyroprocess is proposed at ANL-W). Fission gas treatment proposed for HFEF is similar in function to that in ICPP, so no major environmental differences are anticipated from gaseous releases. (An advantage accrues to the HFEF process, in fact, because the radioactive iodine and carbon-14 are retained as salts and carbides in the solid waste stream, and are not emitted as gases.) Studies have shown that the more active solid fission product wastes have similar volumes between the two processes. A significant environmental benefit may accrue to the HFEF/S process, though, in that the relatively small amount of plutonium that is created during irradiation would be substantially recycled back to the reactor, instead of passing into the calcined waste stream at ICPP.

The modest number of experimental fuel assemblies, most containing plutonium, would be recycled back to the reactor rather than stored. Because of numerous present storage sites and characteristics, it is difficult to compare the differences in environmental impacts from storing irradiated plutonium-bearing fuel assemblies (as is the current practice) versus recycling them. It would seem, though, that returning plutonium to the reactor and fissioning, to produce power, should be environmentally less intrusive than storing the material.

Transportation of nuclear materials would be decreased under the proposed action. The present nuclear materials path (stockpile → EBR-II → ICPP → stockpile, for drivers; and stockpile → EBR-II → indefinite storage, for experiments) would be partially or entirely offset by a regime in which all nuclear materials, except the relatively small amount needed for makeup, stay on the EBR-II site (see Fig. I-1).

NO ACTION * (continue present practice)

* Assumes development of new process at ICPP for U-Zr metal alloy fuel



PROPOSED ACTION

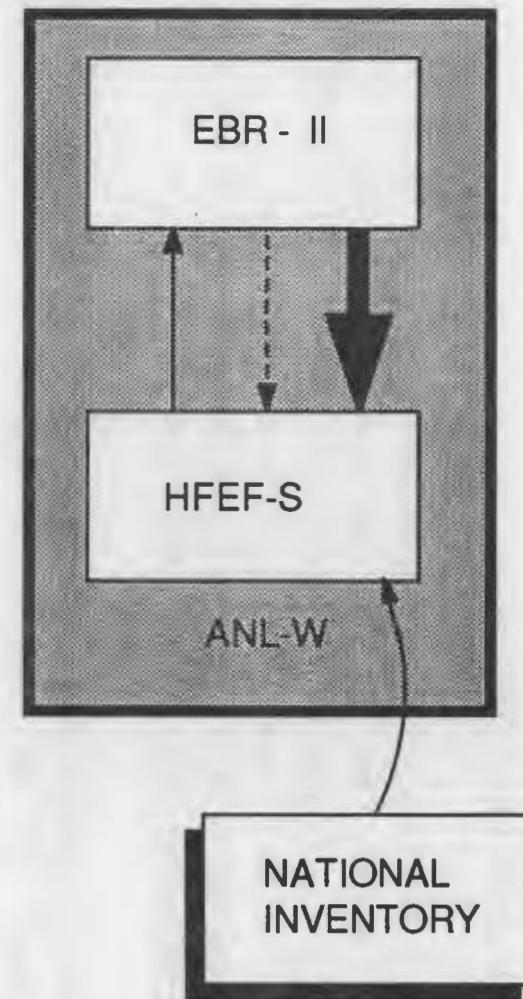


Fig. I-1: Comparison of Transportation in Proposed Action and Present Practice (no action)

II. SITE DESCRIPTION

A. Location of the Proposed Action

The HFEF/S facility is located at the ANL-W site on the INEL government reservation. The INEL is located in the southeast portion of the State of Idaho on the Eastern Snake River Plain (ESRP) (Fig. II-1). The ANL-W site is located in the southeast portion of the INEL reservation (Fig. II-2). The HFEF/S facility, to which the proposed modifications will be made, is located near the center of the ANL-W site (Fig. II-3).

ANL-W is accessible by a single paved road, approximately 5.6 km (3.5 miles) long. This road is open only for official business travel. The intersection of the road and U.S. Highway 20, as shown in Fig. II-2, marks the site boundary.

B. Vegetation and Wildlife

The high desert, treeless plain on which the INEL is located is part of a cool desert shrub biome. Average annual temperature at the INEL is 5.6°C (42°F), with extremes of 39°C (103°F) and -44°C (-47°F). Only two animals classified as endangered or threatened by the Federal government have been observed on or near the INEL; the bald eagle usually winters on or near the INEL and the peregrine falcon has been observed infrequently in the northern portion of the INEL (Ref. V-6). Vegetation is typical of the Great Basin, with sagebrush conspicuous over 80% of the site. Frequenting the INEL are pronghorn antelope, a few deer and elk, coyotes, bobcats, rabbits, large populations of small mammals, and various kinds of birds and reptiles. The DOE has designated the INEL a National Environmental Research Park (NERP) where scientists from DOE, other federal and state agencies, universities, and private research foundations can study changes caused by human activities and obtain data for use in making decisions on land use. In 1987 about 40 different environmental studies were conducted.

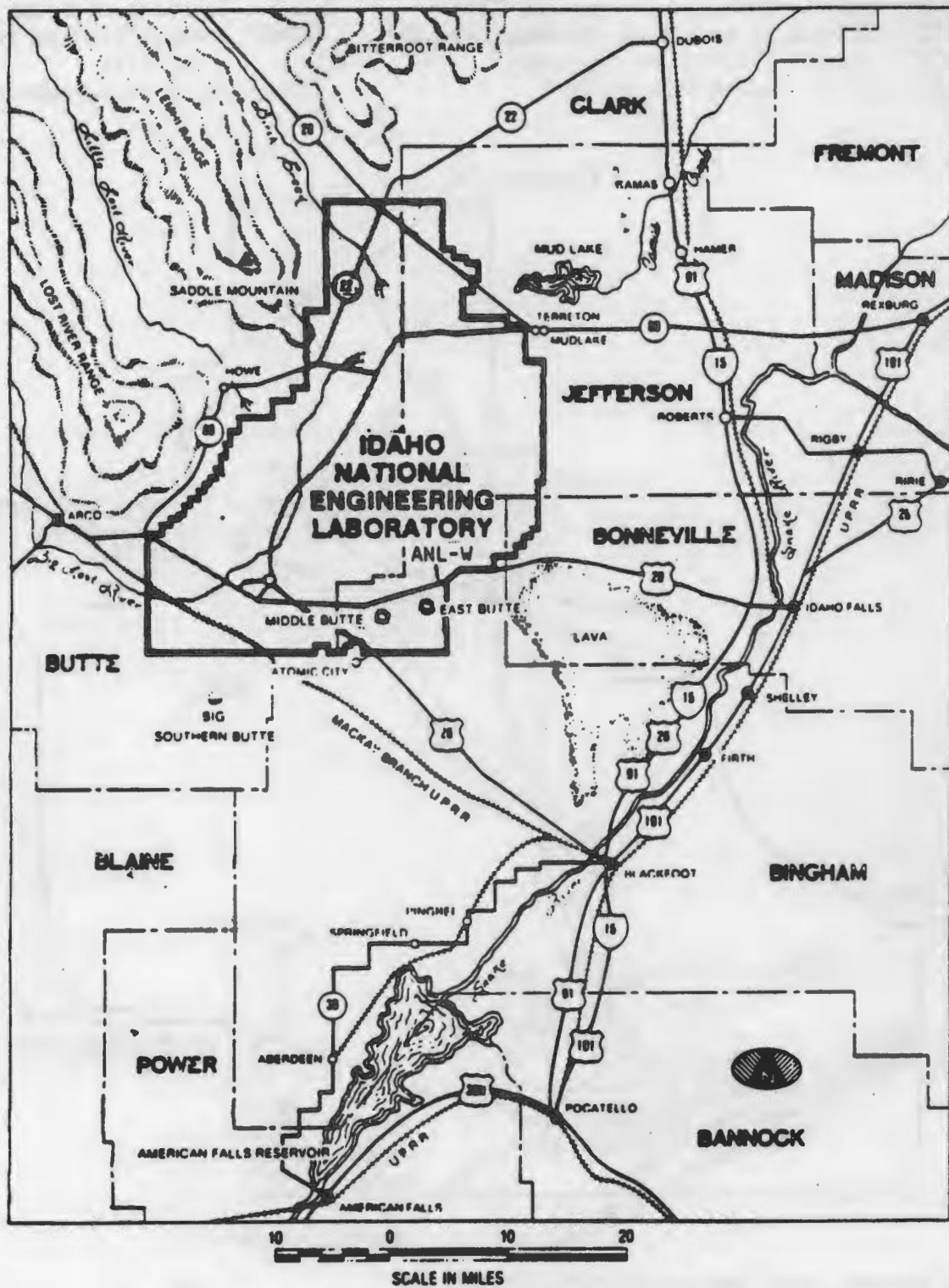


Fig. II-1 Map of Idaho National Engineering Laboratory and Surrounding Area

ANL-W - Argonne National Laboratory-West
 ARA - Auxiliary Reactor Area
 CFA - Central Facilities Area
 EBRI - Experimental Breeder Reactor No. 1
 (National Monument)
 ICPP - Idaho Chemical Processing Plant
 IET - Initial Engine Test (Decommissioned)
 LOFT - Loss of Flow Test Facility
 NRF - Naval Reactors Facility

PBF - Power Burst Facility
 RWMC - Radioactive Waste
 Management Facility
 TAN - Test Area North
 TRA - Test Reactor Area
 TSF - Technical Support Facility
 WRRTF - Water Reactor Research Test
 Facility
 WMO - Waste Management Operations

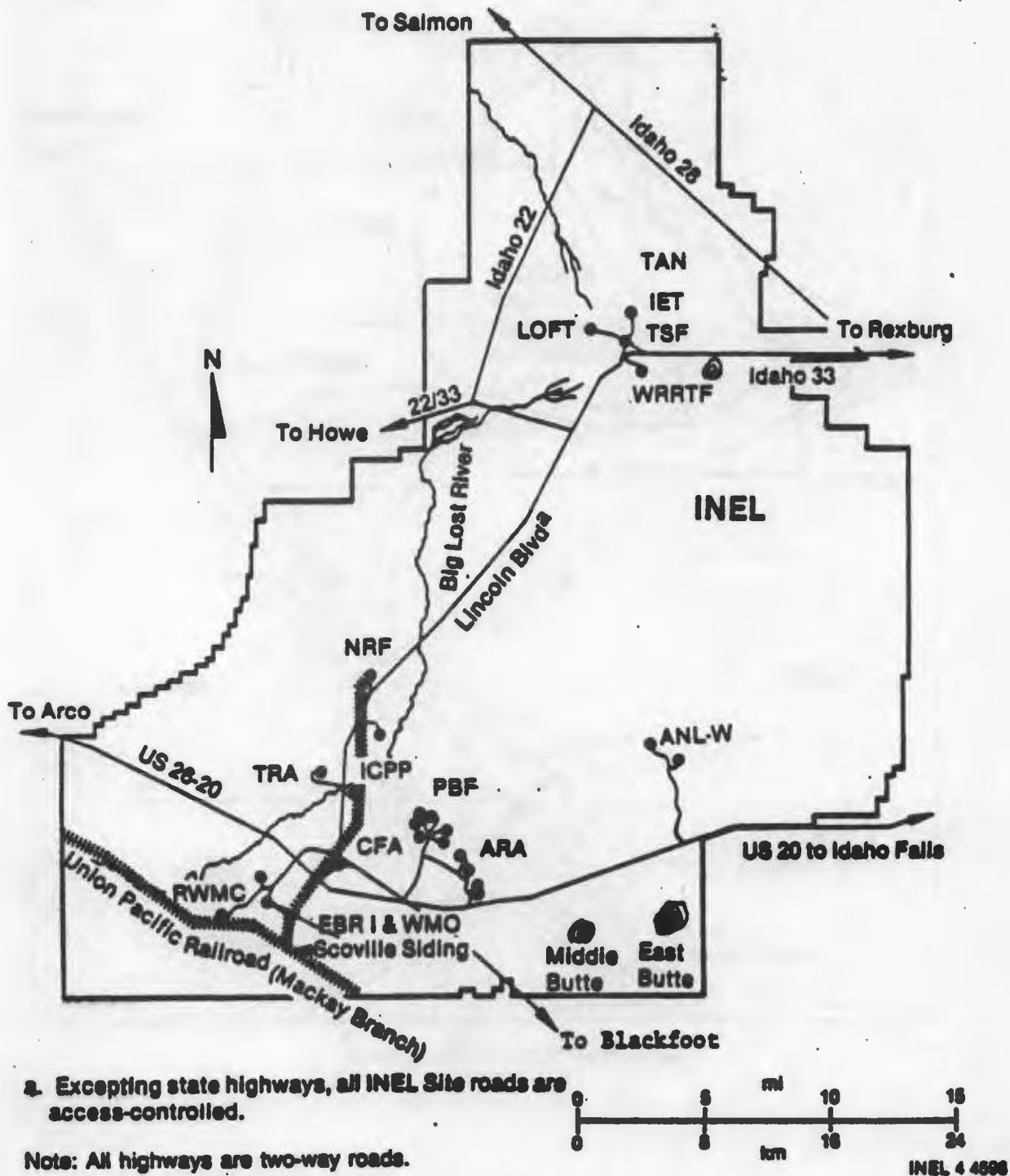


Fig. II-2 Location of Primary INEL Facilities & Relationship to INEL Site Boundary

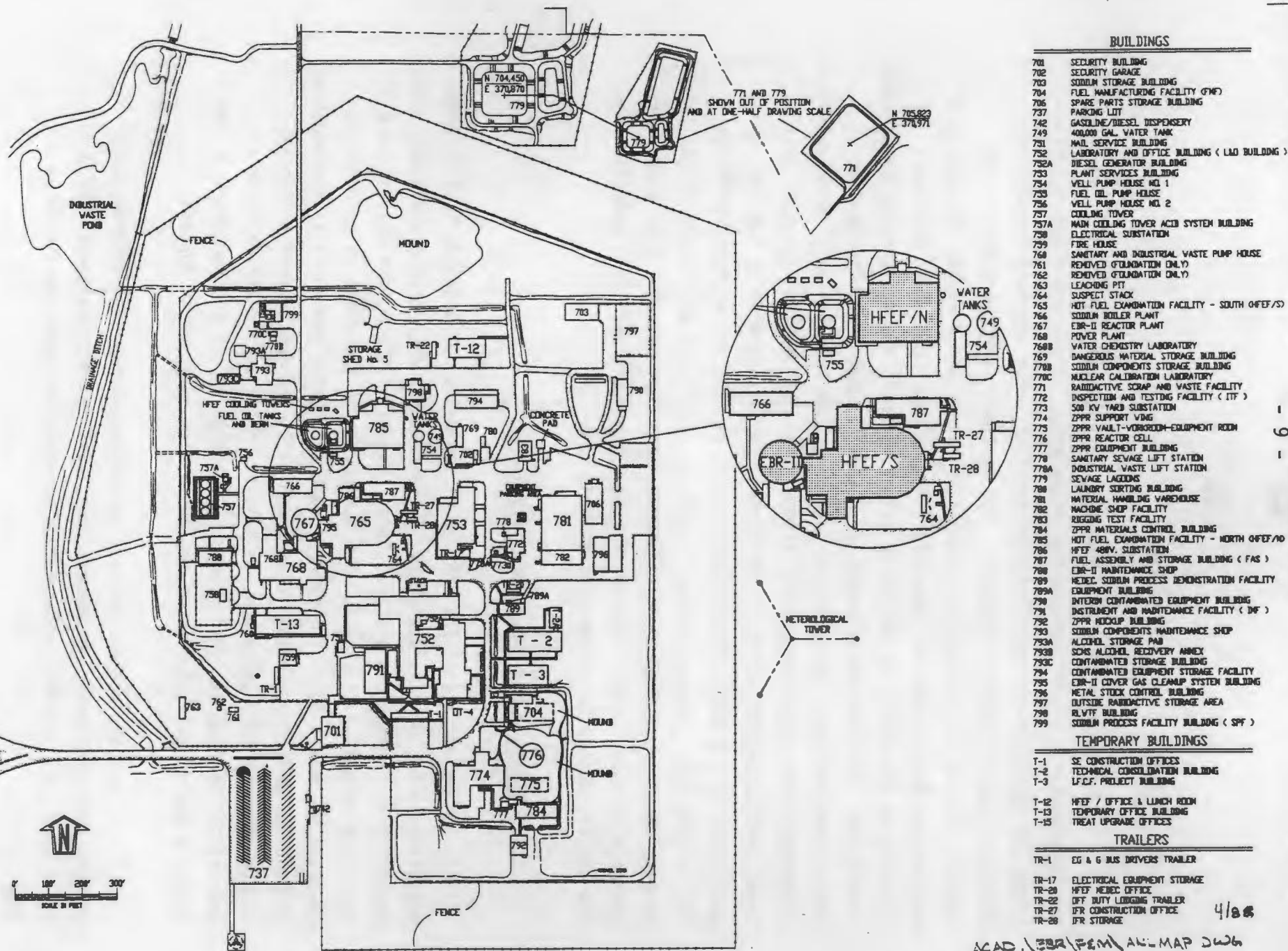


Fig. II-3. Relative Location of ANL-W Facilities.

C. Winds

The nearest INEL site boundary is approximately 5000 m (3 miles) in the southeasterly direction from the ANL-W site. Winds are predominantly along the southwest-northeast axis of the ESRP, with the most frequent and strongest winds from the southwest. The northeast winds are mostly nocturnal. Spring is the windiest time of the year, while winter has more calm periods and more nighttime temperature inversions. Five-year-averaged, directional windspeeds at the ANL-W site for the 75 m elevation, as calculated from actual site data supplied by the National Oceanic and Atmospheric Administration (NOAA) are shown in Table A-1 (see Appendix A). These averaged windspeeds were calculated by the AIRDOS code (see Section V). NOAA data taken over a 32-year period at the Central Facilities Area of the INEL show peak gusts of 126 km/h (78 mi/h) at 6 m (20 ft) and 143 km/h (89 mi/h) at 76.2 m (250 ft). The design basis wind for the HFEF/S modifications has been defined based on site-specific recommendations (Ref. II-1). High wind risks dominate tornado risks at the ANL-W site. Therefore Ref. II-1 guidelines do not specify design to accommodate tornado risks.

D. Geology, Hydrology, and Seismology

The surface of the ESRP is a combination of basaltic lava outcrops and alluvial sedimentary deposits. The sediments range from gravels and sands deposited by streams (as alluvial fans, channel fillings, and deltas) to silts and clays deposited in playas. The subsurface of the plain is principally composed of basalt flows interbedded with lacustrine and alluvial sedimentary deposits to a depth of about 760 m (2500 ft). The most recent volcanism, occurring about 2000 years ago, is evident in the scenic basalt flows at Craters of the Moon National Monument, about 30 km (19 mi) southwest of the INEL. A geological overview of the ANL-W site is given in Appendix F.

The INEL resides between two seismic areas, the Intermountain Seismic Belt and the Idaho Seismic Zone. The seismic design of HFEF/S is based on a site specific acceleration and response spectrum for ANL-W (Ref. II-2).

Data cataloged by the National Geophysical and Solar Terrestrial Data Center of the NOAA indicate that regional earthquakes are historically centered around but generally do not occur on the ESRP (Fig. II-4). However, ground motion produced by earthquakes in the mountains can be transmitted onto the ESRP.

Three earthquakes with magnitudes of about 1.0 have occurred recently on or near the ESRP. (An earthquake of magnitude 1 results in ground vibrations similar to that caused by a large truck driving by.) The first earthquake actually recorded on the INEL occurred on November 27, 1983, with a magnitude of 0.7. The epicenter of this event was about 6 to 8 km (3.7 to 5 miles) east of the Naval Reactor Facility. On February 25, 1983, an earthquake of magnitude 3.2 occurred near the Blackfoot River Reservoir -- just off the ESRP. Three smaller earthquakes (magnitudes of 1.8, 2.0, and 2.2) accompanied this earthquake.

Table II-1 lists the largest historic earthquakes of the region since 1884. The largest earthquake in the Idaho Seismic Zone occurred outside the ESRP on October 28, 1983, and had a Richter magnitude of 7.3. (The energy released in an earthquake of this magnitude is approximate 50% more than in the 1989 San Francisco earthquake.) The earthquake resulted from slippage on a normal range front fault with relative movement down to the west. The epicenter for this event (Fig. II-4) was located along the western flank of Borah Peak in the Lost River Range approximately 64 km (40 miles) northwest of Arco. Although the shock was felt at the INEL, no structural or safety-related damage occurred to INEL structures. Ground accelerations measured at ANL-W were 0.030 g (horizontal) and 0.029 (vertical). Another major earthquake in this region occurred earlier on August 17, 1959 at Hebgen Lake, approximately 100 miles (160 km) from the INEL. This shock had a Richter magnitude of 7.1 and was felt at the INEL but caused no damage.

Annual precipitation at the INEL has averaged 22 cm (8.5 in.) over the past 15 years. Underlying the desert plain is a natural aquifer in the basaltic rock. Aquifer recharge sources include irrigation diversions, valley underflow, river seepage, precipitation, and to a much lesser extent, INEL percolation ponds. A detailed surface and ground water discussions can be found in Appendix G.

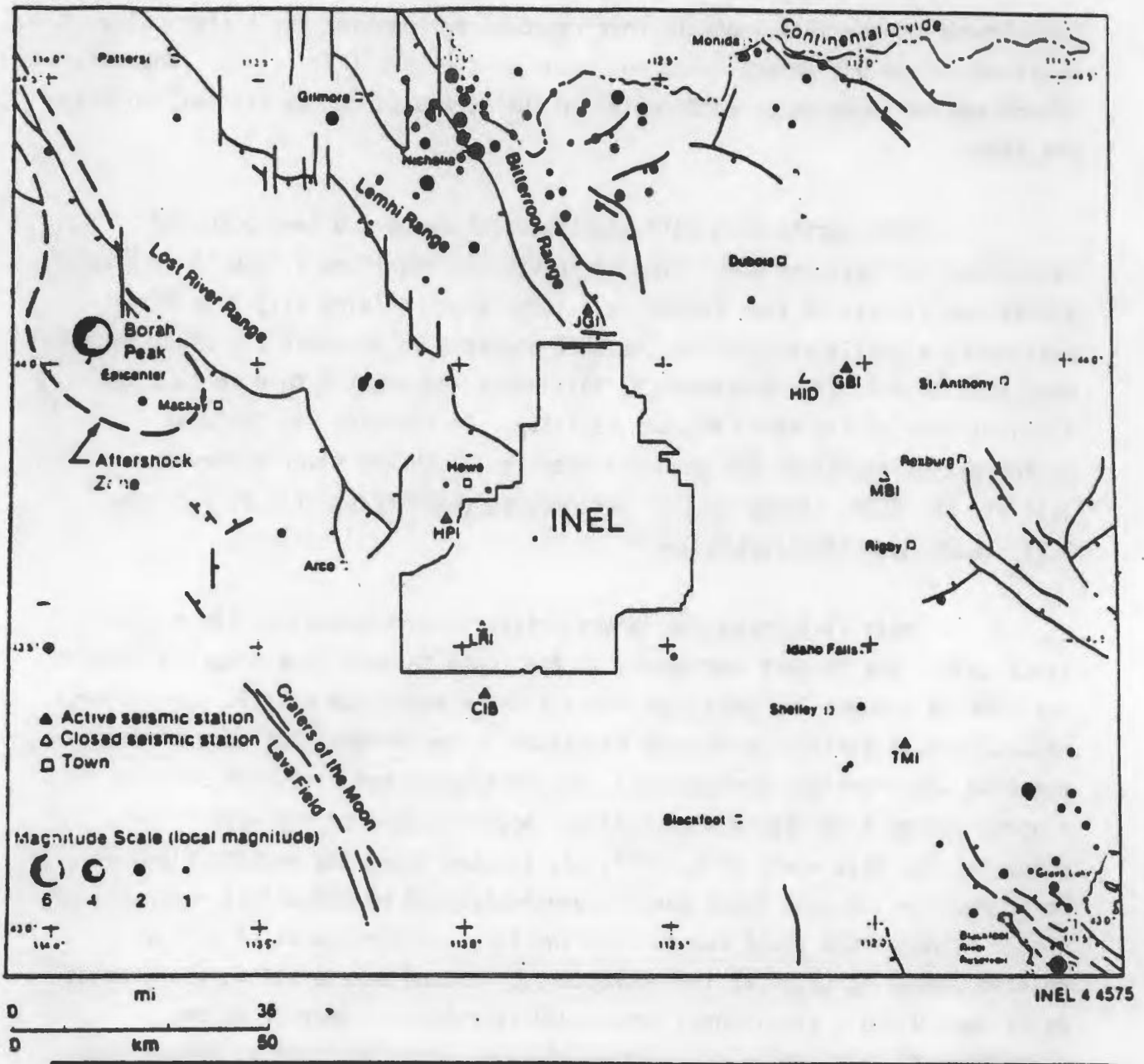


Fig. II-4 INEL Catalog of Earthquakes (from 10/72) including approximate location of epicenter, fault scarp, and aftershock zone (in dashed lines) for the Borah Peak earthquake. (As specified in footnote a of Table II-1.)

TABLE II-1

Largest Historical Earthquakes in General Region
Surrounding the Eastern Snake River Plain^a

<u>Date</u>	<u>Latitude</u>	<u>Longitude</u> °N	<u>Magnitude</u>	<u>Location</u>
November 10, 1884	42.0	111.3	6	Bear Lake Valley, Utah ^b
October 5, 1909	41.8	112.7	6	Hansel Valley, Utah ^b
June 27, 1925	26.0	112.2	6.75	East of Helena, Montana ^b
March 12, 1934	41.7	112.8	6.6 (M _S) ^d	Hansel Valley, Utah ^b
October 18, 1935	46.6	112.0	6.25	Helena, Montana ^b
October 31, 1935	46.6	112.0	6	Helena, Montana ^b
July 12, 1944	44.7	115.4	6.1	Seafoam, Idaho ^b
February 13, 1945	44.7	115.4	6.0	Near Clayton, Idaho ^b
November 23, 1947	44.8	112.0	6.25	Southwestern, Montana ^b
August 18, 1959	44.8	110.7	6	Yellowstone Park, Wyoming ^c
August 17, 1959	44.8	111.1	7.1	Hebgen Lake, Montana ^b
August 18, 1959	44.9	111.6	6.25	Southwestern, Montana ^c
March 27, 1975	42.1	112.5	6.1 (M _S) 6.0 (M _S)	Pocatello Valley, Idaho Utah border ^b
June 30, 1975	44.8	110.6	6.1 5.9 (M _S)	Yellowstone Park, Wyoming ^b
October 28, 1983	44.05	113.89	7.3	Borah Peak, Idaho

^aFrom INEL Characterization Report EGG-NPR-6688, revised January 1985.

^bIncludes mainshocks (or largest swarm events) of magnitude 6.0 or greater (or M.M. intensity VIII for preinstrumental shocks from 1852 through July 1980).

^cPart of 1959 Hebgen Lake earthquake sequence.

^dM_S is the magnitude of surface waves

The underground water moves laterally at an average rate (Ref. II-4) between 1.5 to 6 m per day (5 to 20 ft per day) to the south and west, emerging in springs along the Snake River between Milner and Bliss, Idaho. Discharge volumes from springs in this region are approximately (Ref. II-5) $3.8 \times 5.3 \times 10^9 \text{ m}^3$ ($3.1 \times 4.3 \times 10^6$ acre-ft) per year. Both aquifer and surface waters of the ESRP are used for irrigation of crops. Annual ground water pumpage on the ESRP for irrigation purposes is estimated to total (Ref. II-6) about $1.8 \times 10^9 \text{ m}^3$ (1.5×10^6 acre feet or 4.8×10^{11} gallons).

E. Background Radiation Dose Rate

Background radiation dose rate is reported in Ref. II-3 for an individual located on the ESRP. The background radiation level is estimated as about 250 mRem/yr with radon and its daughter products included, or 150 mRem/yr disregarding radon.

F. Airborne Radioactive Effluent

Estimates of airborne releases of radioactive effluents from total INEL operations are given for calendar year 1987 in Ref. II-3, Table B-12. Table II-2 reproduces the primary isotopes of concern for comparing with HFEF/S estimated releases for the operation of the proposed modifications, discussed in Sections IV and V of this document.

The basic limits that apply to airborne radioactive releases from DOE facilities are those of 40CFR61, Subpart H. This subpart limits the amount of airborne radionuclides released to that which will produce a whole-body equivalent of 25 mRem/y (75 mRem/y to the critical organ) to any member of the public.

Using the AIRDOS-EPA and RADRISK codes, a total-body dose equivalent of 0.034 mRem for 1987 has been calculated for "members of the public at the point of maximum annual air concentration in an unrestricted area where any member of the public resides or abides" (Ref. II-3). This dose equivalent is 0.1% of the EPA airborne radionuclide emission standard. The

TABLE II-2

Total 1987 INEL Airborne Emissions for Selected Isotopes^a

<u>Isotope</u>	<u>Annual Emissions (Ci/y)</u>
Kr-85	< 160,000 ^b
Xe-133	610
H-3	920
Plutonium particulates	2×10^{-5}

^a C-14, iodine, and cesium not listed here since in HFEF/S, except for minute amounts resuspended and/or released or fine dust or vapor from electrowinning/distillation operations, these isotopes are expected to be confined in the solid waste streams.

^b Actual INEL release is classified.

critical organ, the thyroid in this case, is calculated to receive a dose equivalent of 0.36 mRem for 1987, 0.5% of the standard (40CFR61, Subpart H).

III. BASIC PROCESS DESCRIPTION FOR THE PROPOSED ACTION

The basic process closely follows that described in Ref. III-1, but on a much reduced scale. All basic process operations occur in two heavily shielded, confined cells in which all operations are remotely conducted.

Operations in the air cell consist mainly of mechanical disassembly of the fuel assembly into individual fuel elements. The air cell will also be used for assembly of fuel elements into a finished fuel assembly for EBR-II. Some waste preparation operations may occur in the air cell. However, highly radioactive waste will be placed in sealed cans in the argon cell before transfer into the air cell.

The conceptual argon cell processing and fabrication operations, as currently proposed, are shown schematically in Fig. III-1. The details of the process are evolving as the development effort progresses.

Spent fuel elements will enter the argon cell from the air cell via a small transfer lock. The fuel elements, including the cladding, will then be cut into sections with lengths that are compatible with electrorefining. This shearing operation will be performed within local confinement to capture fine fuel particles, but most fission gases (e.g., Kr, Xe, H-3) will be released to the cell.

The sections of fuel and cladding then will be loaded into a basket and will be transferred to the electrorefiner, where in the reference process, the fuel will be dissolved out of the cladding by molten cadmium under a layer of molten salt. The cadmium will serve as the anode of an electrolytic cell and the salt as the electrolyte. Crucibles or solid metal rods suspended in the salt will serve as cathodes and collect uranium and plutonium electrolytically transported from the anode. The electrorefiner operates at 500°C (932°F).

Although details of the electrorefining process are continuing to be developed, the following physical, chemical, and electrolytic processes are expected to occur. During dissolution of the fuel, the residual trapped fission gases will be released to the argon cell atmosphere. The iodine (I) and bromine, which are present in the fuel element as sodium (Na) or cesium (Cs) salts (NaI, CsI, etc.), will combine with the salt layer. Carbon-14 will be present as a carbide such as ZrC. Any tritium and inert fission gases remaining in the fuel or bond sodium will be released to the cell environment. Active fission products from the fuel will react with and become a part of the salt layer. A voltage applied between the molten metal anode and the cathodes will cause electrolytic transfer of uranium and plutonium from solution in the salt and molten cadmium to the cathodes. The noble metal fission products will remain in the molten cadmium anode. The cladding hulls will be stripped of fuel but will be otherwise unaffected. The U-Pu ratio in the cathode product is a function of the material put into the electrorefiner and the operating parameters selected for each batch.

After the electrorefining process has been completed, the cathode will be removed and the deposits of refined fuel will be recovered. The cathode will be heated to the fuel melting temperature [about 1300°C (2400°F)] to volatilize residual cadmium and electrolyte salt from the fuel product. The

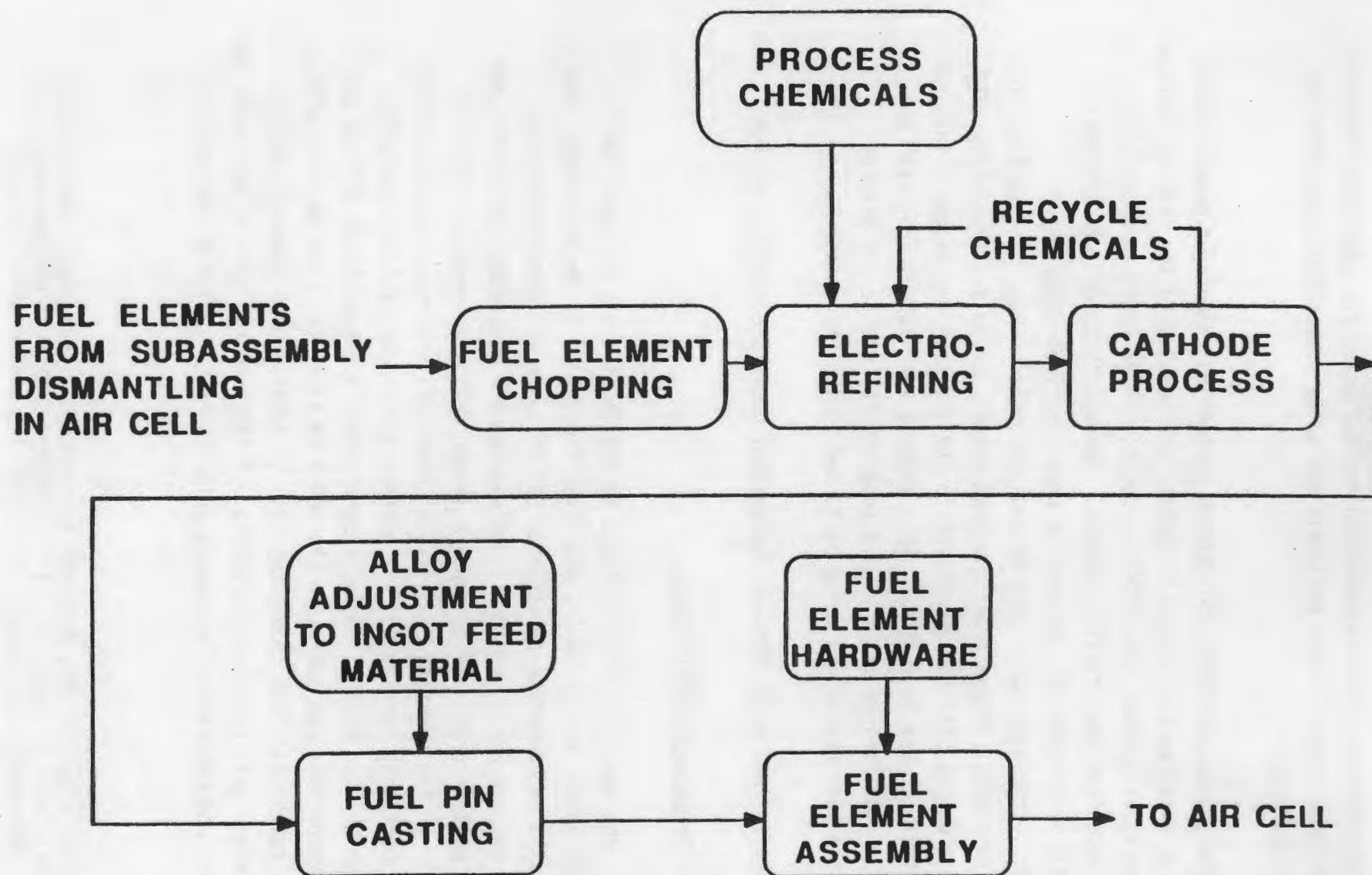


FIG. III-1 ARGON CELL PROCESSING OPERATIONS

volatilized materials will be condensed and collected for additional process use. The metal ingot will be available for alloy composition adjustment and injection casting.

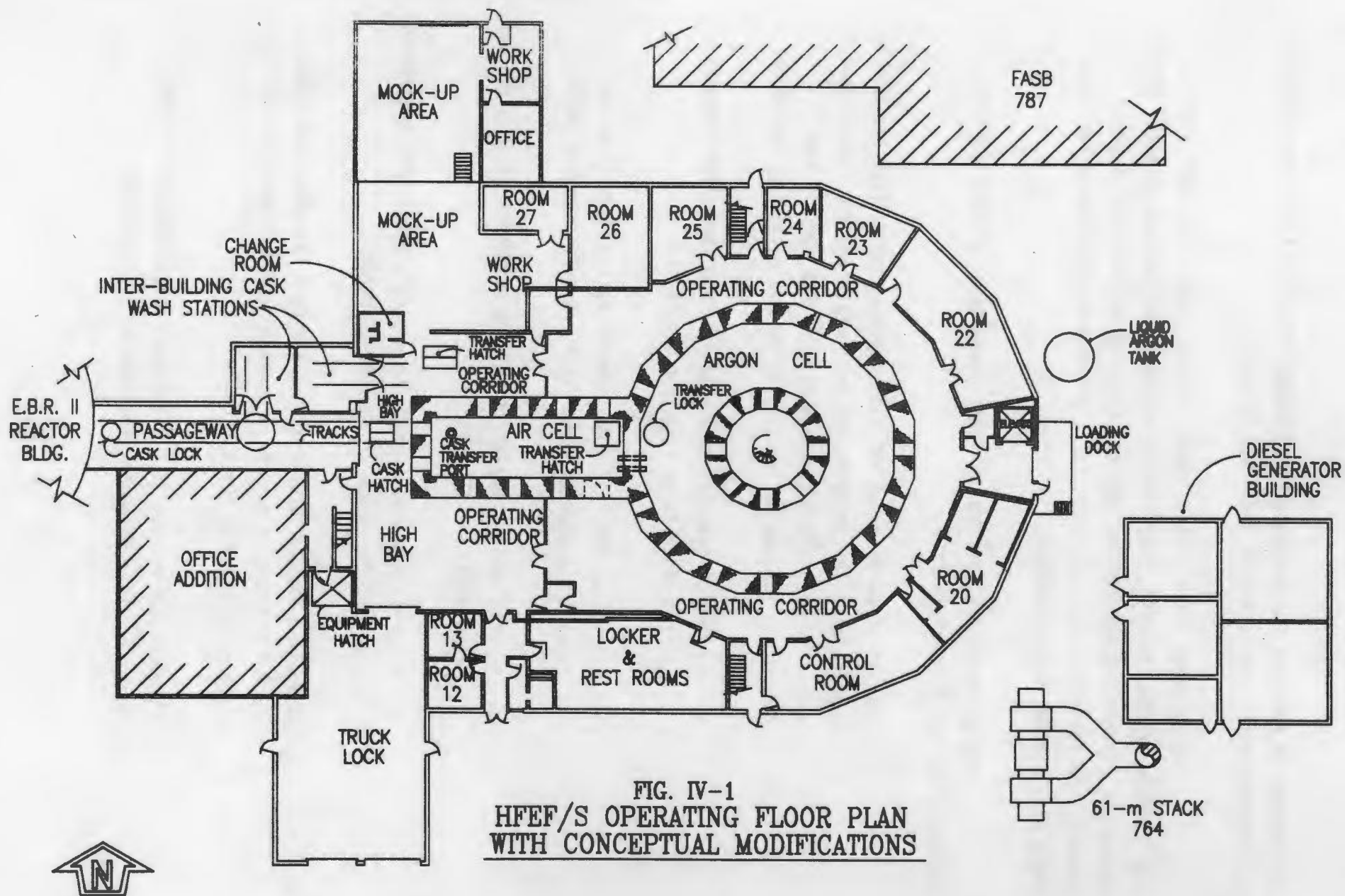
After electrorefining and cathode processing, ingots of product material will be selected for blending together and heating in the casting furnace to a temperature of less than 1600°C (2900°F). This forms an alloy of the desired composition and fissile content. Makeup zirconium, uranium and/or plutonium will be added as required to make the final composition adjustment. This alloy will then be cast into fuel slugs for insertion into new cladding tubes. These tubes are then welded closed and inspected. The completed elements will be transferred to the air cell for assembly into new subassemblies for use in EBR-II. These element fabrication processes are essentially identical to those of the original FCF and to the present unirradiated fuel operations being performed in the FMF at ANL-W.

IV. FACILITY MODIFICATIONS AND CONFINEMENT UNDER THE PROPOSED ACTION

A. Proposed Modifications

The modified HFEF/S [41 m x 52 m (135 ft x 170 ft)] will be arranged as shown in Fig. IV-1*, the first floor plan of the building. The facility will be connected directly to EBR-II by an enclosed passageway. There are two hot cells in HFEF/S, one with an air atmosphere (air cell) and the other with an argon gas atmosphere (argon cell), arranged as shown in Fig. IV-1. In the existing facility, a common wall separates the two cells and their operating corridors. The operating corridors extend completely around both cells. Control rooms, laboratories, and operations offices are located around this corridor. In the modified facility, fire barriers with a personnel access air lock type entry will be installed to separate the air cell and argon cell operating corridors. A large mockup area is available for development and checkout of equipment prior to installation in the cells.

*All drawings shown in this document are conceptual drawings. Even though changes may later be required, it is expected that such changes would not increase emissions significantly or change the environmental control function.



Cask access to and from the building is provided through a truck lock, where cask transporters interface with the facility crane.

The basement floor plan is shown in Fig. IV-2. The radioactive liquid waste system, heating, ventilating and air conditioning systems, inert atmosphere circulating and cooling system, building and air cell exhaust blowers, the subcells below the argon cell, and the new Hot Repair Facility (HRF) are located in the basement.

The primary modifications that are required to prepare for the proposed fuel cycle program are:

1. Install a new basement HRF with improved capability for confined repair of contaminated hot cell equipment and discontinue use of an existing hot repair area on the roof of the facility. The new HRF would provide the following functions:
 - a. A path for transfer of equipment, supplies, and contact-handled waste to or from the hot cells.
 - b. A location for remotely decontaminating, handling, and examining equipment after it is removed from the cells.
 - c. A location for remotely repairing equipment using glove box techniques.
 - d. A location where personnel can safely enter with protective clothing for hands-on equipment repair.
2. Install a bag-out system at the air cell transfer cask interface for improved control of contamination spread during transfers of items from the air cell.
3. Upgrade and isolate (i.e., enclose) the radioactive liquid process system from the remainder of the facility.

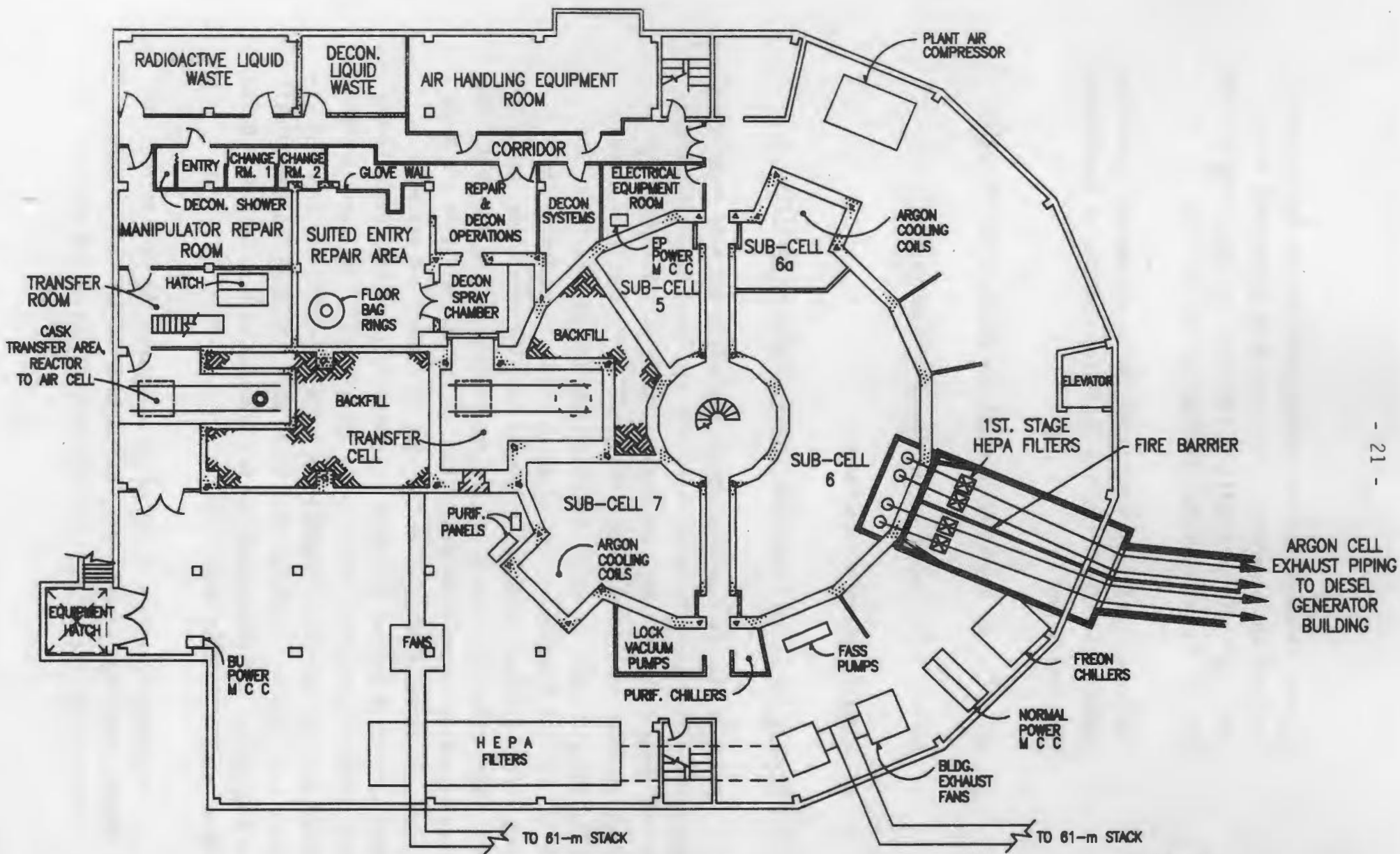


FIG. IV-2
HFEF/S BASEMENT FLOOR PLAN
WITH CONCEPTUAL MODIFICATIONS

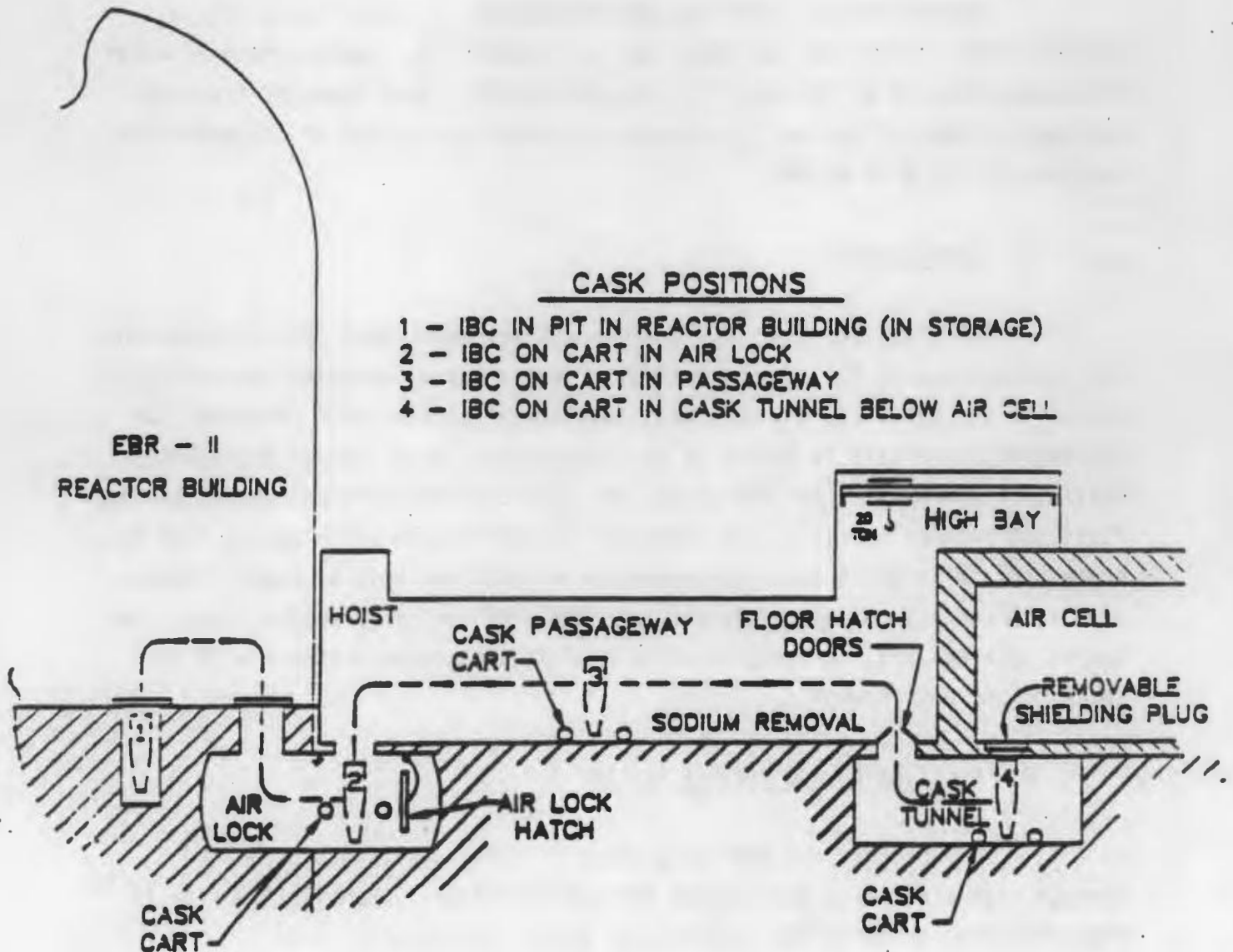
LEGEND:
DECON = DECONTAMINATION
EP = EMERGENCY POWER
FASS = FIXED AIR SAMPLING SYSTEM
MCC = MOTOR CONTROL CENTER
PURIF = PURIFICATION SYSTEM

4. Upgrade the operating corridors so that the air cell/argon cell corridors are separated. This will help assure that an accidental contamination spill in the argon cell operating corridor will not spread into the remainder of the facility.
5. Improve air cell confinement sealing to accommodate plutonium contamination resulting from increased handling of experimental fuel assemblies.
6. Install a new argon cell exhaust and pressure relief system.
7. Install a new backup diesel-generator power system.
8. Install new process equipment.

B. Description of Fuel and Waste Transfer Paths in Facility

All fuel transfers between EBR-II and HFEF/S are made in existing shielded casks called inter-building casks (IBC's). Fuel assemblies are loaded into these casks in EBR-II and transferred to HFEF/S through the passageway as shown in Fig. IV-3. In HFEF/S, the fuel assembly is washed inside the IBC with water to react and remove any sodium adhering to the outside of the fuel elements, or contained in the crevices inside the assembly. After washing, the cask is lowered into the cask tunnel using the facility crane, placed on a transfer cart and moved under the air cell. The cask then is sealed to the floor penetration in the air cell with a plastic sleeve (this is termed a "bag-in" or "bag-out" procedure and has been developed to protect against spread of contamination) and the fuel assembly is withdrawn from the cask into the cell. In the air cell, the assemblies are dismantled and the individual elements are transferred into the argon atmosphere cell through a transfer lock which passes through the common wall between the cells. Recycled assemblies are transferred back to EBR-II by the same route, and in the same cask.

Equipment transfers to the cells go through the HRF, through the spray chamber, into the transfer cell, and up into the air cell or argon cell. Transfers into the air cell are made directly using the air cell



MOVEMENT OF INTERBUILDING CASK BETWEEN EBR-II AND HFEF/S

Fig. IV-3

crane. Transfers into the argon cell (because of its inert atmosphere) are made through a large transfer lock. Air is pumped out of the lock and replaced with argon gas before the lock is opened to the argon cell. Equipment transfers out of the cells to the HRF are transferred by the same route. Decontamination, if needed, is done in the spray chamber before the equipment enters the HRF.

Remote-handled waste is transferred out of the air cell into a shielded cask in the same way that fuel is transferred. Contact-handled waste is transferred out of the facility through the HRF. Both types of transfers are made through a "bag out" arrangement to avoid the spread of contamination outside the air cell or HRF.

C. Confinement

At least two levels of confinement are maintained during processing and transporting of fuel in the facility. Where loose contamination routinely exists in the facility, any innermost confinement barrier with potential for contamination release is backed up by a second barrier.* During transport of fuel and waste outside the hot cells, the fuel clad or waste can serves as the first confinement barrier. All areas of the facility in which unclad fuel is processed, or in which loose contamination exists, are held at negative pressure with respect to the environment and the surrounding operating areas. The operating areas are, in turn, normally held at a negative pressure with respect to the environment.

D. Ventilation and Off-Gas Systems

All process and operating areas of the facility are exhausted through high efficiency particulate air (HEPA) filters. Ventilation flow is from the clean areas to the contaminated areas. Areas with loose

*This should not be interpreted to mean that no single contamination barriers will exist. Barriers that are of substantial construction and that have no routinely accessed penetrations (e.g., the argon cell roof) are designed as a single barrier.

contamination (i.e., argon cell, air cell, HRF, and subcell 4) are normally exhausted through two stages of testable filters in the air cell exhaust system (Note: the argon cell is normally sealed except for a small purge flow and any atmosphere that escapes from the lock operations). Other areas are normally exhausted through a single stage testable filter.

Ventilation systems employ redundant exhaust blowers and operate continuously. They will be designed to survive the failure of a single active component or control function, and so that HEPA filters can be changed without interrupting required flow and filtration.

Air atmosphere areas that confine loose contamination are provided with HEPA filters at the ventilation inlet and the outlet of these areas. This will help keep ventilation outlet ducting at low contamination levels and will accommodate an upset flow reversal through the area ventilation inlet.

A new argon cell exhaust system will be provided for the off-normal event where the cell pressure rises above acceptable limits. The system also exhausts the subcells below the argon cell. If a loss of argon cell inert atmosphere occurs, in the unlikely event that the cell boundaries are breached and a metal fire subsequently initiates, this system will ensure that any resulting releases are filtered. The system is being designed with redundancy of active components and power supplies to ensure high reliability, single failure resistance, and resistance to damage by design basis natural phenomena.

All air atmosphere areas of the facility are normally exhausted to a 61 m (200 ft) stack via the building or air cell exhaust systems. Therefore, almost all normal release of radioactivity will be via this stack. The argon cell (which has no normal exhaust except for a small purge flow*) and subcell areas will also be exhausted to the 61-m stack. The conceptual interrelationship between the ventilation/ off-gas systems is shown

*The purge flows to the 61 m (200 ft) stack.

in Fig. IV-4. Figure IV-5 shows a preliminary concept of the new argon cell/subcell exhaust system.

E. Electric Power

Normal electric power will be supplied by the INEL grid or from the EBR-II turbine-generator, depending upon whether the reactor is on line. EBR-II is capable of supplying up to 35% of the INEL's total electricity demand of 250,000 MW-hr annually.

The facility will be provided with two diesel-generators, primarily to supply backup power to ventilation systems. These supplies are to be located outside the main process building, and will replace the single unit now in the basement of the facility (where it presents a possible facility fire initiation source). The arrangement will provide power that is capable of withstanding a single failure. It will be necessary to construct a building in a "previously disturbed" location adjacent to the main process building to house these backup power sources, and to provide shelter for the new argon cell exhaust and pressure relief and stack monitor systems.

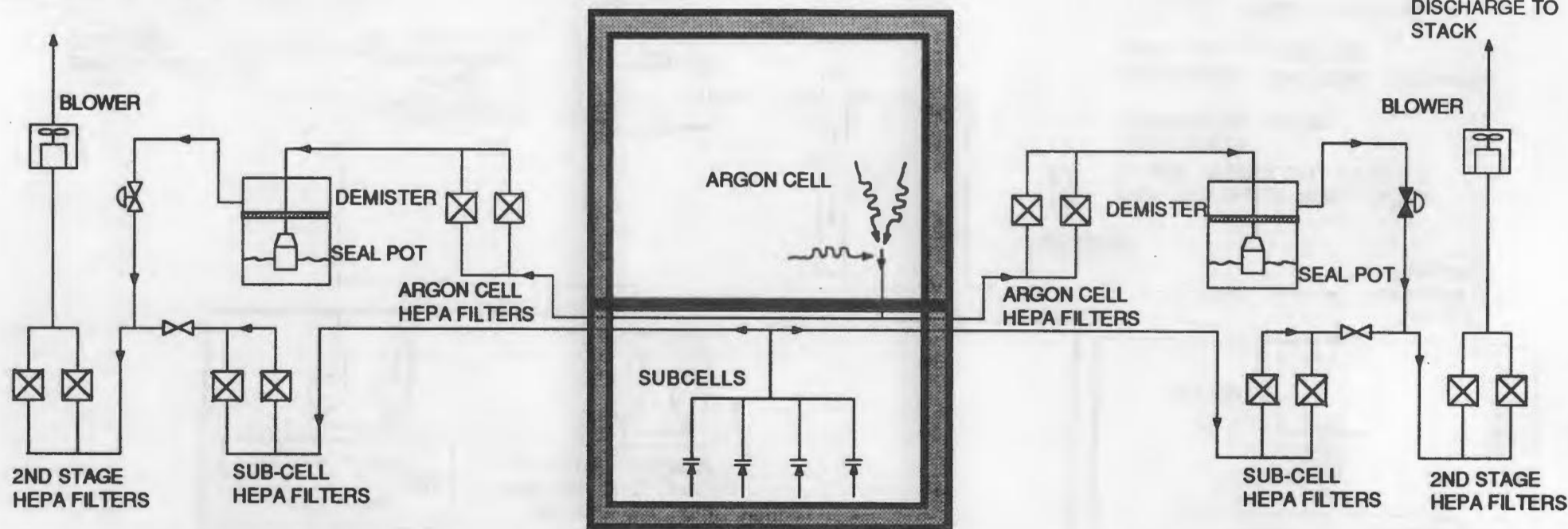
F. Resistance to Natural Phenomena

Although the facility is considered moderate hazard, it has been subjected to analysis according to high-hazard natural phenomena criteria, as defined in Ref. IV-1. A high hazard facility is generally considered to pose a greater hazard than moderate hazard facilities due to the potential for more widespread and/or long-term contamination in the event of off-site release of radionuclides. This potential might be due to the presence of large quantities of in-process or toxic materials having a high energy source, or due to the presence of transport mechanisms that facilitate off-site dispersion of these materials (Ref. IV-1). The guidelines for high hazard facilities call for selection of design basis natural phenomena that have annual probabilities of exceedance no greater than 0.0002 and 0.0001, respectively, for earthquake and high winds. At the ANL-W site these correspond to an earthquake with a ground acceleration of 0.21 g and a windspeed of 42.5 m/s (95 mi/h). An increased exceedance probability is allowed for existing



**FIG. IV-4 SIMPLIFIED EXHAUST SYSTEMS
CONCEPTUAL DIAGRAM**

DISCHARGE TO STACK



* NOTE- ONE BLOWER OPERATES CONTINUOUSLY
WITH AUTOMATIC SWITCHOVER TO OPPOSITE
BLOWER ON LOSS-OF-FLOW

LEGEND

- AUTOMATICALLY CONTROLLED VALVE IN ACTIVE TRAIN
(NORMALLY CLOSED- OPENS ON HIGH CELL PRESSURE)
- AUTOMATICALLY CONTROLLED VALVE IN STANDBY
TRAIN - NORMALLY OPEN FOR PASSIVE PRESSURE RELIEF
- CHECK VALVE
- DOP - TESTABLE HEPA FILTER

FIG. IV-5 SIMPLIFIED CONCEPTUAL SCHEMATIC
OF ARGON CELL EXHAUST AND PRESSURE
RELIEF SYSTEM

facilities, but this credit will not be taken in HFEF/S unless absolutely necessary.

The building, cell structures, and foundation have been analyzed for a site-specific, design-basis earthquake. A three-dimensional finite element model of the structure was generated and a dynamic analysis (response spectrum analysis) was performed. Three orthogonal directions of seismic input were summed with the dead and live loads to evaluate the seismic integrity of the structure.

It was concluded that the basic portions of these structures would survive the earthquake without damage. Although not analyzed in detail, some failures or cracking might occur in penetrations (e.g., cell penetrations, building windows) and internal building partitions. The argon cell exhaust system will be designed to operate after the earthquake to provide inflow through any breaches in argon (process) cell penetrations that are not earthquake-hardened, therefore inhibiting backward migration of contamination from the cell. In the event the argon cell atmosphere is lost, this system will also be designed to filter any products-of-combustion that might result from a metal fire accident within the cell. As a defense-in-depth measure, the individual high-temperature metal process confinements (e.g., furnace boundaries) are also being designed to survive the design basis earthquake.

The heavily shielded cells are more than adequate to survive the site-specific design basis wind. However, the analyses to-date indicate some minor weakness in a small portion of the outer building structure of the facility. If more detailed analyses indicate that the problem persists, it will be easily corrected by minor bracing additions. This will be done before the facility is started up.

The backup electric power sources will be hardened against design basis natural phenomena. The argon cell exhaust system will also be hardened against these phenomena.

G. Design Standards

Where applicable, design has been conducted in conformance with DOE Order 6430.1A "General Design Criteria Manual", as revised 12/25/87, and with the resolution of comments (November, 1988).

V. EFFECTS ON THE ENVIRONMENT

A. Air Quality

Releases to the environment during construction will be minimal. Most excavation activities are conducted within the HFEF/S building, with facility ventilation systems operating. Therefore, particulates generated by these modification activities will be filtered before being exhausted to the atmosphere through the facility stack. Local dust collection will be employed where the potential for spread of contamination inside the building exists (e.g., due to removal of a small layer of concrete from the surface of contaminated concrete floors and walls).

Occupational exposures from radioactivity in suspended particulates will be controlled by local dust (particulate) collection using large vacuum sweepers and by partitioning off work areas. Personnel will be further protected by the use of air suits or respirators. Data taken from particulates collected in continuous air flow monitors (CAM) during previous decontamination work indicate no problem in controlling exposures from radioactivity in the particulates. Concentrations measured with the CAMs, relative to the allowable for a controlled area, were more than a factor of ten lower for mixed alpha radionuclides, and more than a factor of one million lower for mixed beta-gamma emitters.

All soil removed from the facility will be checked for radioactivity. Based on core drilling samples, very little contaminated soil is expected to be found. However, at isolated locations, such as near cold joints in the existing basement concrete, there will be a small amount of contaminated soil. All soil removed from the facility will be checked. Any soil that is found to be contaminated will be shipped to the Radioactive Waste

Management Complex (RWMC). Uncontaminated soil will be sent to an INEL landfill.

Construction equipment will generate air pollutants in the process of excavating and backfilling for the small diesel generator building. Trucks, used to transport excavated material from inside and outside the building, and for transport of radioactive waste from the facility modifications, will also generate air pollutants. Using primarily the emission factors identified in Ref. V-1, integrated emissions for the entire construction period are estimated to be the following:

carbon monoxide -	216.2 kg
hydrocarbons -	243.6 kg
nitrous oxides -	663.8 kg
sulphur oxides -	100.4 kg
particulates -	141.8 kg

These releases are very small compared to the INEL overall release estimates. For instance, the nitrous oxide and sulphur oxide total construction release estimates are only 8.1 and 3.0 percent, respectively, of the 1987 average weekly release from the whole INEL.

Dust would be released during construction of the diesel generator building and during transport of excavated material. Because the transport of excavated material occurs primarily on paved highway, dust generation during transportation is assumed to be dominated by loss of material from the beds of trucks and during dumping. Although no definitive data could be found to use in this assessment, the loss is assumed to be less than 0.1% of the loose material (i.e., dirt) that is transported, or dust generation of about 5.4 metric (6.0 English) tons. If dust becomes a problem, construction areas and truck loads would be wet down or covered.

Dust would also be generated directly by construction activities related directly to excavation for, and erection of, the diesel-generator building. Estimates of airborne release from these activities are based on a conservatively estimated area of less than one acre involved in new

construction activities related to the new building and an emission factor of 1.09 metric (1.2 English) tons/acre (from Ref. V-1) per month for construction activities related to apartment and shopping center projects. The dust release from this latter source in the projected four month building construction period is therefore estimated as 4.4 metric (4.8 English) tons, and the total fugitive dust release from both of the above sources is therefore estimated to be less than 9.8 metric (10.8 English) tons.

The following discussion considers radioactive releases, both gaseous and particulate, and nonradioactive releases from operation of the HFEF/S modifications. Unless otherwise noted, these discussions are in consonance with the facility's 40CFR61.07 National Emission Standards for Hazardous Air Pollutants (NESHAPS) application for construction or modification (Ref. V-2) that has been approved by the EPA, and with the Prevention of Significant (Air Quality) Deterioration (PSD) construction permit application (Ref. V-3) that has been approved by the State of Idaho.

Incremental airborne releases of radioactivity from the modified facility will originate from two sources (Ref. V-2):

- Particulate release consisting of very small amounts of uranium, plutonium, and solid fission products which escape through the facility exhaust HEPA filters.
- Fission product gases consisting primarily of Kr-85 (because of long delay times for radioactive decay before processing) and tritium as both water vapor and gaseous forms.

1. Particulate Radioactive Release

All particulate release from operating and processing areas will be filtered by high efficiency particulate attenuation (HEPA) filters before being exhausted. Exhaust from areas normally confining unclad fuel and/or loose contamination is filtered by two tested stages and exhaust from other areas is filtered by at least one tested stage. Therefore, considering

the assumed HEPA filter retention efficiency of ≥ 0.999 per stage, only very minute amounts escape. For estimates of particulate release during normal operation, an attenuation factor of 1×10^{-3} per stage, and a total of 1×10^{-6} for two stages, has been assumed herein. Any stage for which such credit was taken will be DOP-testable while in place.

Particulate generation rate has been estimated using 1) early pilot-scale process experience for fine particulate release, in processes similar to those planned in the argon cell, and 2) an estimate of resuspension from contaminated surfaces in the argon cell and all other areas normally containing loose contamination based on the previous, less confined, metallurgical operations in the argon cell.

The source term of heavy metal (U, Pu) and fission products entering the facility was estimated using the ORIGEN code. The ORIGEN computer code, in the application here, calculates fission product and actinide mass variations due to nuclear transmutations, during both reactor irradiation and during fuel cooling (reactor shutdown or out-of-reactor) periods. The code accounts for nuclear fission, neutron activation, and for radioactive decay, and will track the variations in the amount of each significant isotope due to the various source or loss channels. It has been defined as a suitable source for fission product and actinide inventories by DOE radiological accident guides (Ref. V-13).

The basis for the estimates was the processing of 60 EBR-II U-Pu-Zr subassemblies per year, irradiated to 10% heavy metal burnup. This should be very conservative for plutonium estimates, since less than 20% of the fuel assemblies processed are now projected to contain a significant amount of plutonium. That is, more than 80% will contain only U-Zr as the metal fuel.

The estimated annual radioactive particulate release is shown in Table V-1. Since these estimates were made (based on early process developments), there have been three changes in conceptual process conditions which could increase the particulate generated. These are: 1) increase in

TABLE V-1

Annual Radioactive Particulate Release Estimates
for Average Annual Processing Rate of 60
Fuel Assemblies^a

<u>Type of Radiation</u>	<u>Estimated Annual Release (Ci)</u>
Alpha (e.g., U,Pu)	0.4×10^{-8}
Beta and Beta-Gamma (e.g., fission products)	1.8×10^{-6}

^a From Table X-1 of Ref. V-2; see Appendix A for details of constituents. For estimated release at maximum annual processing rate of 90 fuel assemblies these values should be increased by a factor of 1.5.

salt and cadmium inventory in the electrolyzer, 2) change from a quaternary to a binary salt (which increases the cadmium vapor leaking through the salt), and 3) changes in the amount of cadmium distilled per unit of fuel processed in the cathode processor. However, as noted in Section V.A.3, the effective whole body dose from radioactive particulate release to an observer at the INEL site boundary is projected as only 0.003% of the total dose. It is therefore very unlikely that any increase in total dose, due to possible future changes in design and particulate release, will be significant.

Table A-2 (see Appendix A) shows the calculated radionuclide activities present in an EBR-II fuel assembly, 450 days after discharge from the reactor. The initial fuel charge was a Pu-U-Zr metal fueled fuel assembly similar to that expected to be processed in HFEF/S (see Appendix A) and the fuel assembly was irradiated at a power of 1.0 MW for 422 days. Table A-2 also gives estimates of annual particulate release (from Ref. V-2) for each isotope of significance, for the processing of 60 fuel assemblies per year. Data pertinent to the release calculation are given in Appendix A.

Using the methods described previously the release estimates predicted that, except for the very short lived radionuclides, airborne release by resuspension of surface contamination would dominate over release from process dust. Surface contamination is expected to be "aged", i.e., at any given time it will be a buildup from past operations. For this reason, the surface contamination radionuclide activities were evaluated for 450 days after irradiation instead of 100 days* (i.e., the time at which activities are evaluated for estimates of normal release as "dust" from fuel processing).

In evaluating the release of radioactive particulates from the argon cell (both as process dust and as resuspended contamination), credit was taken for the benefit of the HEPA filters in the cell recirculation/cooling system in maintaining a low equilibrium cell atmosphere particulate concentration. This system recirculates $4.7 \text{ m}^3/\text{s}$ ($10,000 \text{ ft}^3/\text{min}$) of cell atmosphere through the HEPA filters which exchanges the complete cell volume every 6.6 minutes. Because these particular HEPA filters cannot be tested while in place, a very low efficiency (70%) was assumed. A surface contamination resuspension rate of $10^{-9}/\text{s}$ was assumed (see Ref. V-16) based on the fact that the average atmosphere velocity through most of contaminated areas is expected to be less than 2.2 m/s (5 mi/h).

2. Gaseous Fission Product Release

The gaseous fission product source was also estimated using the ORIGEN code. It has been assumed that all gaseous fission products brought into the facility are to be released to the atmosphere. This may not be completely accurate, since the project may collect Kr-85, to the extent practical, in a demonstration recovery system. However, it is conservative to assume the system is not operating.

Based on Ref. V-12 (p. 54) and measurements made by EBR-II personnel, it is estimated that 90% of the tritium generated during irradiation would diffuse through the fuel cladding while in the reactor.

*100 days is the minimum waiting time before fuel is expected to be transferred into the facility under normal operating conditions.

Therefore only 10% would enter the HFEF/S facility. Except for small particulate releases, C-14 and the iodines, which are normally at least partially released by aqueous reprocessing plants, are expected to be retained in the solid waste streams. The annual gaseous fission product release estimates are given in Table V-2.

3. Combined Radiological Dose

The overall estimated annual radiological doses from operation of the HFEF/S modifications are shown in Table V-3. These doses were estimated using the annual radiation release previously discussed. The AIRDOS-RADRISK codes were used to estimate the doses in accordance with 40CFR61. The AIRDOS-RADRISK code is appropriate for these calculations because it accounts for multiple pathways (i.e., inhalation, immersion, ingestion) in evaluating the radiological dose, and is specifically called out as an acceptable modeling procedure in the code of Federal Regulations, 40CFR61, Subpart H, "National Emission Standards for Radionuclide Emissions from DOE facilities."

Although the AIRDOS-RADRISK code can be used to calculate radiological doses according to the (older) International Committee on Radiological Protection (ICRP) Publication 2 techniques (Ref. V-14), effective whole body doses, as reported herein, are calculated as weighted sums over the body organs and in accordance with the more recent ICRP Publication 30 dose conversion factors (Ref. V-15). The total effective whole body equivalent dose (AIRDOS-RADRISK) "weighted sum"* is estimated as 3.8×10^{-7} Rem/y** to an observer at the INEL site boundary. This is only 0.0015% of the 40CFR61, Subpart H, limit of 25 mRem/y for DOE facilities, and only 0.00015% of estimated ESRP background radiation dose (see Section II.E).

*All references to "effective whole body equivalent" dose in this section are actually the AIRDOS-RADRISK "weighted sum."

**For a peak annual processing of 90 fuel assemblies, this value should be multiplied by a factor of 90/60 or 1.5.

TABLE V-2

Annual Gaseous Fission Product Release Estimates^a
for an Annual Processing Rate of 60 Fuel
Assemblies

Isotope	Estimated Annual Release (Ci)
Kr-85	9780
Xe-131 ^m	157
Xe-133	7
H-3	66

^a From Ref. V-2.

TABLE V-3

Annual Site Boundary Radiological Dose Estimates
from Operation of HFEF/S^a for an Annual
Processing Rate of 60 Fuel Assemblies

Source	Estimated Effective Whole Body Dose (Rem/y)
Particulates	1.1×10^{-11}
Gaseous Fission Products (including tritium)	3.8×10^{-7}

^a From Ref. V-2.

A strict comparison with the limit of 25 mRem/y of 40CFR61, subpart H, would use the "total body dose" instead of "effective whole body (equivalent)" dose. However, for the specific mixture of radionuclides released from HFEF/S these two doses are calculated to be nearly identical. Therefore, the use of effective whole body (equivalent) dose, as directed by a DOE internal memorandum, is a suitable substitute.

The results of AIRDOS-RADISK radiological dose calculations are sensitive to modeling assumptions. Since the original HFEF/S calculations were performed, a protocol for modeling was established for the INEL Fuel Processing Restoration (FPR) Project. The results of dose calculations using this protocol, summarized in Appendix A, show that the estimated particulate dose is increased, but that the total dose is reduced. Since the particulate dose is such a small portion of the total, moderate variations in this dose are inconsequential.

The worker dose rates from the operation of HFEF/S can be estimated from the current data on HFEF/N workers. For the year 1987, the average HFEF/N worker whole-body dose was 0.09 Rem. The highest average exposures were for the cask handling crew (0.57 man-Rem/y) and the master/slave maintenance crew (0.23 man-Rem/y). Exposures for HFEF/S personnel are expected to be in this range.

4. Nonradioactive Airborne Release

Operation of the modified facility is estimated (Ref. V-3) to release 54.5 kg (120 lb) annually of freon, from electrical equipment cleaning operations. This amount is considered to be inconsequential by present standards. Conservatively assuming a stack flow rate of $14.2 \text{ m}^3/\text{s}$ ($30,000 \text{ ft}^3/\text{min}$) and that freon cleaning operations are conducted only 20 hours per year, a freon concentration of only $53 \text{ mg}/\text{m}^3$ is estimated in the stack exhaust, which compares with the current American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) of $7600 \text{ mg}/\text{m}^3$ (Ref. V-4). At the site boundary much lower concentrations would be observed due to dilution by diffusion even if the wind were blowing directly toward the boundary. The regulatory (Idaho) threshold for "significant" release is

3.63×10^4 kg/yr (40 ton/yr) for volatile organics, much larger than the projected 54.5 kg/yr (120 lb/yr) freon release from HFEF/S modifications. This HFEF/S release is therefore considered much too small to have a measurable effect on the population or the environment. However, it is prudent to minimize the effect of freon on the stratospheric ozone layer and HFEF/S will continue searching for a suitable substitute. There will be additional freon release from the cell cooling system (approximately 91 kg [200 lbs] per year for maintenance), but this is an existing system and is not being significantly modified.

Cadmium, an EPA proposed hazardous air pollutant, will be used in the electrolyzer and will be distilled to separate heavy metal in the cathode processor. Because cadmium vapors are confined in areas where fuel processing occurs and releases are filtered by two series stages of HEPA filters before exiting the facility, releases from the modified facility will be extremely small. Sources in these processing areas have been estimated using techniques similar to those described previously for radioactive particulates; that is, as fine dust floating in the argon cell released directly from the processes, and as resuspended surface contamination. The filtration efficiency is estimated as 0.999 for each of the two stages of HEPA filtration. The estimated release from the stack to the atmosphere is less than $1 \mu\text{g/y}$. At this release rate, and a conservatively assumed $14.2 \text{ m}^3/\text{s}$ ($30,000 \text{ ft}^3/\text{min}$) flow rate to the stack, a concentration of $2.2 \times 10^{-12} \text{ mg}/\text{m}^3$ is estimated in the stack exhaust, a factor of 2.23×10^{10} less than the ACGIH time weighted average TLV of $0.05 \text{ mg}/\text{m}^3$ (Ref. V-5). Concentrations of cadmium at the site boundary would be greatly reduced from these already insignificant levels. Therefore, airborne cadmium release will not have a measurable effect on population or the environment, even though there is a high uncertainty on the estimates.*

*As discussed in Section V.A.1, there are contemplated changes in process inventories, a change in salt composition, and the amount of cadmium distilled per unit of metal processed. These may combine to increase the cadmium released from the facility over that projected here. However, even a factor of several thousand increase would not affect the conclusions herein because of the extremely low release quantities. It should be noted also that the EPA has not identified any sources of cadmium emissions for regulation nor proposed any emission standards.

Other nonradioactive pollutants emitted by the modified facility during operation are organics used during cleaning operations (e.g., alcohol andalconox) and backup power diesel-generator emissions. Volatile organics released from cleaning operations are estimated at 91 kg/yr (200 lb/yr), exclusive of any minor increase due to surface wipedowns. Because of increased diesel-generator testing requirements over those originally planned (in order to accommodate the high reliability assurance needed for the argon cell exhaust system), the estimated diesel-generator emissions are increased over the original estimates in Refs. V-2 and V-3. The diesel-generator emissions were previously estimated from the 1985 EPA standard for over-the-road engines, except for SO_x which was based on 0.4 weight percent sulfur in fuel actually delivered to the ANL-W site and operation for up to 40 hours per year at partial output. Emissions are now based on 60 hours of operation annually for each generator.* For this assessment the emission factors of Ref. V-1, as tabulated for diesel-powered industrial equipment, have been adopted. The exception is that the SO_x emissions have been estimated based on 0.4% sulphur in diesel fuel. It is now assumed that the diesel generators require full-output testing to meet safety requirements. The estimated total of non-radioactive emissions** are shown in Table V-4, together with a listing of state de minimus levels and 1987 INEL releases. It should be apparent from Table V-4 that the HFEF/S estimated non-radioactive emissions do not add significantly to the total INEL emissions.

B. Socioeconomic Impacts

The total estimated project cost of \$19 million for the construction and equipment (excluding engineering) is low compared to most prior or present projects on the INEL. The Fuel Processing Restoration (FPR) project, for example, involves costs of roughly a factor of 20 times higher than those of HFEF/S. For this reason, the socioeconomic effects in

*The State has allowed, in the PSD permit, operation for up to 120 hours to provide operational flexibility. The current nominal estimate is 60 hours.

**These are facility releases only. Indirect releases such as those generated while producing steam and electricity at other facilities in support of HFEF/S are not included.

TABLE V-4

Estimated Non-Radioactive Airborne Release from Operation of
HFEF/S Modifications

Criteria Pollutant	State Deminimus Level	HFEF/S Est. Annual Release	1987 INEL Release
CO	100 tons/y	0.23 tons/y ^a	---
NO _x	40 tons/y	1.04 tons/y ^a	469 tons
SO _x ^b	40 tons/y	0.11 tons/y ^a	191 tons
Volatile Organics ^c	40 tons/y	0.26 tons/y	---
Particulate	25 tons/y	0.074 tons/y	---
Cadmium	---	<1x10 ⁻⁶ g/y ^d	---

^aSO₂ estimate based on fuel assay, CO and NO_x estimates based on EPA emission standards for industrial diesel equipment.

^bSO_x calculations based on SO₂.

^cIncludes 120 lb/y freon, diesel-generator exhaust hydrocarbons and aldehydes, and 200 lb/y alcohol oralconox cleaning solutions.

^dAirborne emissions through HEPA filters.

communities surrounding the INEL are expected to be insignificant. No general commercial or industrial growth specifically associated with the proposed action is expected.

No significant economic impact from operating HFEF/S in its modified mode is expected. An increased work force of no greater than 20 additional people is foreseen, which might add up to 60 citizens to the local community population. The average annual population increase in the six counties adjacent to the INEL is about 2100 persons (Ref. V-6), so the increment associated with HFEF/S operations is insignificant (2.9% of the expected growth for a single year). Existing area housing and municipal service systems have sufficient capacities to accommodate future population growth (Ref. V-6).

C. Electric Power

The major new electrical loads required to support operation of the proposed actions are:*

- Argon cell cooling
- Operation of argon cell exhaust system blowers and refrigeration
- Operation of the argon cell atmosphere purification system
- Power to heat air for the shielded hot air drum evaporator (SHADE)
- Pumping power for new cooling water requirements
- Power for process furnaces

The total is estimated as less than 3×10^6 kW-h annually, or less than 10% of present ANL-W site usage. EBR-II generates electricity for the ANL-W site and sells its excess electricity to Idaho Power Company for use in the INEL grid. Excess power from EBR-II in FY87 was approximately 83,000 MW-hrs. The added requirements to support the HFEF/S modifications, 3000 MW-hrs, is estimated to decrease the available excess power by less than 4%.

D. Cooling and Other New Water Requirements

Principal new water requirements for the modified HFEF/S would include recycle water for cooling systems, additional potable water for the increased number of employees, and water for the SHADE. Recycle water is cooled in an auxiliary cooling tower so only makeup of evaporation loss is needed from groundwater pumpage. The additional groundwater pumpage required for HFEF/S would be less than 5680 m^3 (1,500,000 gal) per year. This amount is less than 1% of the present ANL-W annual groundwater pumpage. The Snake River Plain aquifer discharges to the Snake River at a rate of approximately $4.5 \times 10^9 \text{ m}^3$ (1.19×10^{12} gal) annually average (Ref. II-5). The added requirements in groundwater pumpage will be well within the capacity of the

*One possible electrical load might be for an alternative (to SHADE) design thin-film evaporator that would require approximately 83 MW-hr annually.

Snake River Plain aquifer, representing approximately 0.00013% of the amount available for discharge to the Snake River. A summary of the principal new annual water requirements is listed below:

- Makeup water for recycle evaporation in the following cooling systems (less than 1,200,000 gal/y)
 - process furnace power supplies,*
 - vapor condenser in the SHADE exhaust,
 - cell atmosphere purification system exhaust, and
 - argon cell cooling system heat rejection.
- Potable water for 20 new employees requiring 0.163 m^3 (43 gal) each per day (Ref. V-7) (1173 m^3 [310,000 gal, including 50% uncertainty]).
- Evaporator feedwater (114 m^3 [30,000 gal]), including 50% uncertainty).

E. Process Steam

Total steam demand may be increased over present demand in order to condition the inlet air to the facility SHADE and for equipment cleaning purposes. Based on a 107°C (225°F) inlet air temperature and an air flow rate of $0.0944 \text{ m}^3/\text{s}$ ($200 \text{ ft}^3/\text{min}$), the evaporator heating requirements will correspond to an annual energy input of approximately 86,000 kW-hr, possibly as a combination of steam and electric heating. It is conservatively assumed here that all 75.7 m^3 (20,000 gal) of water processed through the spray chamber would be supplied as saturated steam. These requirements correspond to use of less than $3.2 \times 10^5 \text{ kg}$ ($7 \times 10^5 \text{ lbs}$) of saturated steam per year. Comparatively, the ANL-W site used approximately $3.9 \times 10^7 \text{ kg}$ ($8.5 \times 10^7 \text{ lbs}$) of saturated steam for process and building supplies in FY87. Steam would be obtained from either the EBR-II reactor turbine inlet or from ANL-W boilers.

*If the furnace power supply cooling water cannot be recycled (e.g., due to corrosion product crud buildup in the water), an additional 700,000 gallons of once-through water may be required. However, it is likely that most of this water would be returned to the aquifer after percolation and earth-filtering since it would be rejected to the industrial waste pond.

F. Effect on Threatened and Endangered Species

No endangered species are resident on the INEL and no critical habitats have been designated. However, two animals that are classified as endangered or threatened by the Federal government have been observed on or near the INEL. The bald eagle usually winters on or near the INEL and the peregrine falcon has been observed infrequently in the northern portion of the INEL (Ref. V-6). No impact on either species would be expected.

G. Effect on Historical and Archeological Resources

All construction would take place within the ANL-W perimeter fence, a previously disturbed area. Therefore, there is only a very small chance of any effect on historical or archeological resources. If any artifacts of historical or archeological resources were discovered, all activities would be halted until appropriate authorities were consulted.

H. Visibility

The only significant particulate emissions would be from testing the diesel generators. There would be no plume from the 61-m stack, and no effect on visibility at any location outside the ANL-W site.

I. Noise

Existing noise levels at the ANL-W site are very low and the proposed action would not be expected to add significantly to the total noise level. Noise generated during construction by jackhammers, etc., inside the building would be attenuated by the building structure and basement walls to an acceptable level at locations nearby. The primary noise-generating activities within the building will be completed prior to beginning excavation for the diesel-generator (D-G) building. During construction of the D-G building, noise would be generated by trucks and earth moving equipment such as backhoes and front loaders. Due to the small size of the diesel-generator building, the number of pieces of equipment that must operate at the same time would be minimal. It is estimated that only one backhoe or front-loader and

two trucks will be required. Devices of this type have shown noise levels in the range of 72 to 93 dBA at 15.2 m (50 ft) (Ref. V-8).

If it is assumed that these equipment items are operating simultaneously, each with noise levels of 90 dBA at 15.2 m (50 ft), the overall noise level would be estimated as 95 dBA. However, more typical energy-equivalent noise levels, at construction sites with minimal equipment, are a maximum of 83 dBA during ground clearing with a second highest level of 77 dBA during erection of foundations (Ref. V-8). Since only a minimum of ground clearing is required, the nearby energy-equivalent construction noise level is assumed to be 77 dBA (although instantaneous levels could exceed this value, as previously discussed).

The period over which such noise levels would exist for only a few weeks, since only about 1530 m³ (2000 cubic yards) of earth must be moved for construction of the D-G building. If necessary, this brief period can be accommodated by temporarily relocating nearby non-project personnel. The Argonne-West Health and Safety Manual (Ref. V-11) has limits on the time that workers may be exposed to continuous noise. These time limits begin at 80 dBA and are progressively less as the noise level increases, with no exposure allowed in excess of 115 dBA.

Since the construction site approximates a point source, the construction noise would be expected to be attenuated according to the square of the distance to the receptor. Assuming the maximum predicted level of 95 dBA at 15.2 m (50 ft) from the equipment, the estimated maximum site boundary noise level would be approximately 45 dBA. This is less than the day-night weighted average noise level at a quiet suburban residential district (Ref. V-8).

During normal operation of the facility, there would be no major sources of noise and most of the minor sources come from equipment that is already existing. Minor noise is generated by operation of forklifts and/or trucks and the ventilation system within the buildings. However, during testing or during power outages, noise would be generated external to the main building by the new diesel generators housed inside a small adjacent building.

A typical diesel generator, with vibration isolation and intervening structural walls, generates weighted noise levels of approximately 56 dBA (Ref. V-8). For HFEF/S the two diesel generators would operate simultaneously upon loss of normal power, with an approximate noise level of 59 dBA. With the assumption that this noise level would be applicable at a distance of 7.6 m (25 ft), and that the noise level is attenuated as the square of the distance to the observer, the nearest-site-boundary noise level from these sources is estimated to be only 3 dBA.

J. Sampling of Environmental Release

For the 61 m (200 ft) stack, a continuous monitor is presently provided to sample radioactive gaseous and particulate release to the environment. After modification, the stack will include a new fixed-filter-alpha radioactivity monitor and Kr-85 monitor which would cover the primary concerns from HFEF/S fuel processing.

Both the ANL-W industrial waste pond and sanitary sewage lagoon are periodically sampled and analyzed for radioactivity. The industrial waste pond is periodically sampled and analyzed for hazardous ions, elements, and pH. The sanitary sewage lagoon is periodically sampled and analyzed for biochemical oxygen demand, dissolved oxygen, and pH.

K. Land Use

The size of the existing HFEF/S building would change slightly. The relatively small diesel generator building, constructed adjacent to the facility, would change the present footprint. All construction would be within the "previously disturbed" area defined by the ANL-W site perimeter fence, and most construction would occur within the existing HFEF/S building. New underground tanks are not presently proposed for the diesel generator fuel supply, but if such tanks are used they will meet the EPA requirements of 40CFR280 and 40CFR281, September 23, 1988.

L. Impacts of the Decontamination and Decommissioning

Since the principal impact of decontamination and decommissioning of the modified facility will be the generation of radioactive wastes, these considerations are discussed in the waste section of this assessment (VI.F).

M. Unavoidable Impacts from Operation of Facility Modifications

Operation of the modified facility would result in contamination of the processing and equipment decon/repair areas of the facility and would result in the the airborne release of minute amounts of radioactivity and cadmium through the ventilation system filters and main facility stack.

A small increase in groundwater pumpage would be necessary primarily to provide for cooling water makeup and to support new personnel. Additional electric energy will be needed to operate facility and process equipment.

Solid radioactive, contact-handled, remote-handled, transuranic, and hazardous mixed waste would be generated as a by-product of fuel processing. Some freon, and small amounts of volatile organics from equipment cleaning and decontamination operations would be released from the stack.

Operating diesel-generators would emit the small amounts of the standard pollutants to the air, which are included in Table V-4. These generators are small and would be operated only for testing of capability and during normal power outages.

The above impacts are minimal, as would be expected from a facility that processes fuel from only one small research reactor. It is important to note that EBR-II reactor is an operating power reactor and the fuel will be processed elsewhere on the INEL if not processed in this facility. Therefore the total INEL emissions, resource usage, and waste generation should not be significantly changed by the use of the modified HFEF/S facility. The only notable exception would be the use of cadmium in the HFEF/S processes and its presence in solid waste streams, producing mixed-hazardous waste. However, there would be inconsequential releases of cadmium to the environment.

Liquid radioactive wastes would be retained in the facility or at the adjacent RLWTF facility until they were evaporated. Therefore, there would be no release of radioactive liquids to the environment.

N. Relationship to Executive Orders on Protection of the Environment

HFEF/S is located in a high desert plain and is not located within a flood plain as defined in Executive Order 11988 nor on wetlands as defined in Executive Order 11990.

VI. WASTE GENERATION AND ACCOMMODATION

A. Solid Process Wastes

Table VI-1 shows the projected waste forms that would arise from operation of HFEF/S based upon the process developments cited in Refs. V-2 and V-3. Because the processing experiments are intended as well to optimize the overall IFR fuel cycle, some variations in operation may occur to permit such demonstrations as actinide burning,* complete removal of transuranics from the salt waste, and production of specific waste forms. Variations in processing schemes can affect the volume and weight of waste produced, and future commercial IFR considerations will likely mandate the demonstration of waste immobilization prior to acceptance for disposal.

Because of the uniqueness of the IFR fuel cycle, the direct waste forms would not all fall under current definitions for waste categories. For example, certain of the wastes would fall into the 10CFR60.2 (Ref. VI-1) high level waste (HLW) classification, even though the classification is written for liquid wastes from the first stage of aqueous reprocessing. There are no liquid wastes from IFR fuel processing, but "equivalent" salt and metal wastes are generated. The Project will process these and all other wastes into a form suitable for disposal. Because the wastes will be dry and compact, they

*"Actinide burning" is the process of recycling the waste actinides back to the reactor to "burn" them, and thus reduce the source of long-lived radioactivity in the waste.

TABLE VI-1

Summary of Nominal Process Solid Waste Characteristics (Preliminary)

Waste Form	TRU	EP Toxic Waste (Cd)	Elem. Sodium	Interim Storage	Final Disposal ^d
1. Fuel Assembly Hardware	No	No	No	RWMC	RWMC
2. Electrolyte Salt Waste	Yes	No ^a	No	RSWF ^c	CR
3. Crucibles and Molds	Yes	No ^a	No	RSWF	CR or WIPP
4. Fuel Element Plenums	Yes	No	Yes ^b	RSWF	CR or WIPP
5. Metallic Wastes and Fume Traps	Yes	Yes	No	RSWF	CR

^aPreliminary classification, assumes near-complete separation of cadmium.

^bElemental sodium reacted prior to final disposal.

^cRCRA Treatment, Storage, or Disposal (TSD) Part B facility permit required. Application being prepared for submittal with overall INEL RCRA package.

^dCR = Civilian Repository; DOE may direct some of the experimental wastes to WIPP; if wastes were directed to WIPP, interim storage would be at either RWMC or RSWF.

can (and will) be stored in retrievable containers. At any time prior to transfer to ultimate disposal, the waste can be retrieved for repackaging if so required by emerging criteria.

Table VI-2 presents a likely range of waste product generation. The table shows two sets of values for throughput and waste generation, the first being a nominal value, based on implementation of waste minimization techniques. The second set of values represents an upper bound estimate, assuming maximum possible throughput as well as operational upsets requiring equipment cleanout.

Because of low generation rates and extremely low radiotoxicity, it is planned that the gaseous wastes from the fuel processing demonstration will all be released to the atmosphere via the 61 m (200 ft) stack. In a future commercial reprocessing plant, this would not be done, as a consequence of the much greater throughput. Therefore, in order to make the demonstration of metal fuel processing in the modified HFEF/S facility broadly representative

TABLE VI-2

Estimated Annual Direct Process Wastes
from EBR-II/IFR Fuel Processing in
the HFEF/S Argon Cell

	Nominal Estimate	Upper Bound Estimate ^{a,d,e}
<u>Process Load</u>		
Number of Fuel Assemblies Processed per Year	60	90
Average Burnup, atom percent	10 ^b	10 ^b
Average Cooling Time, days ^c	360	90
<u>Metallic Wastes</u>	<u>Weight (in kg)</u>	
Cd [U, Pu, Noble Metal Fission Products]	90	750
Zr	30	45
Cladding (fueled and plenum regions)	175	260
Anode Baskets	12	15
Subtotal	307 kg	1070 kg
<u>Electrolyte Salt Wastes</u>	<u>Weight (in kg)</u>	
Electrolyte [(U, Pu) Cl ₃ , Rare Earth Fission Products, Cs, Sr]	115	400
<u>Process Hardware Wastes</u>	<u>Weight (in kg)</u>	
Quartz Molds	35	50
BeO Crucibles	20	30
Fume Traps	15	20
Process Equipment	500	1900
Subtotal	570 kg	2000 kg

^aAssumes the subsequent installation of waste treatment equipment not presently included in facility or programmatic planning.

^bActual burnup may exceed this value; if so, the number of sub-assemblies processed annually will decrease proportionately.

^cMaximum fuel assembly heat generation load allowed at transfer is 500 watts.

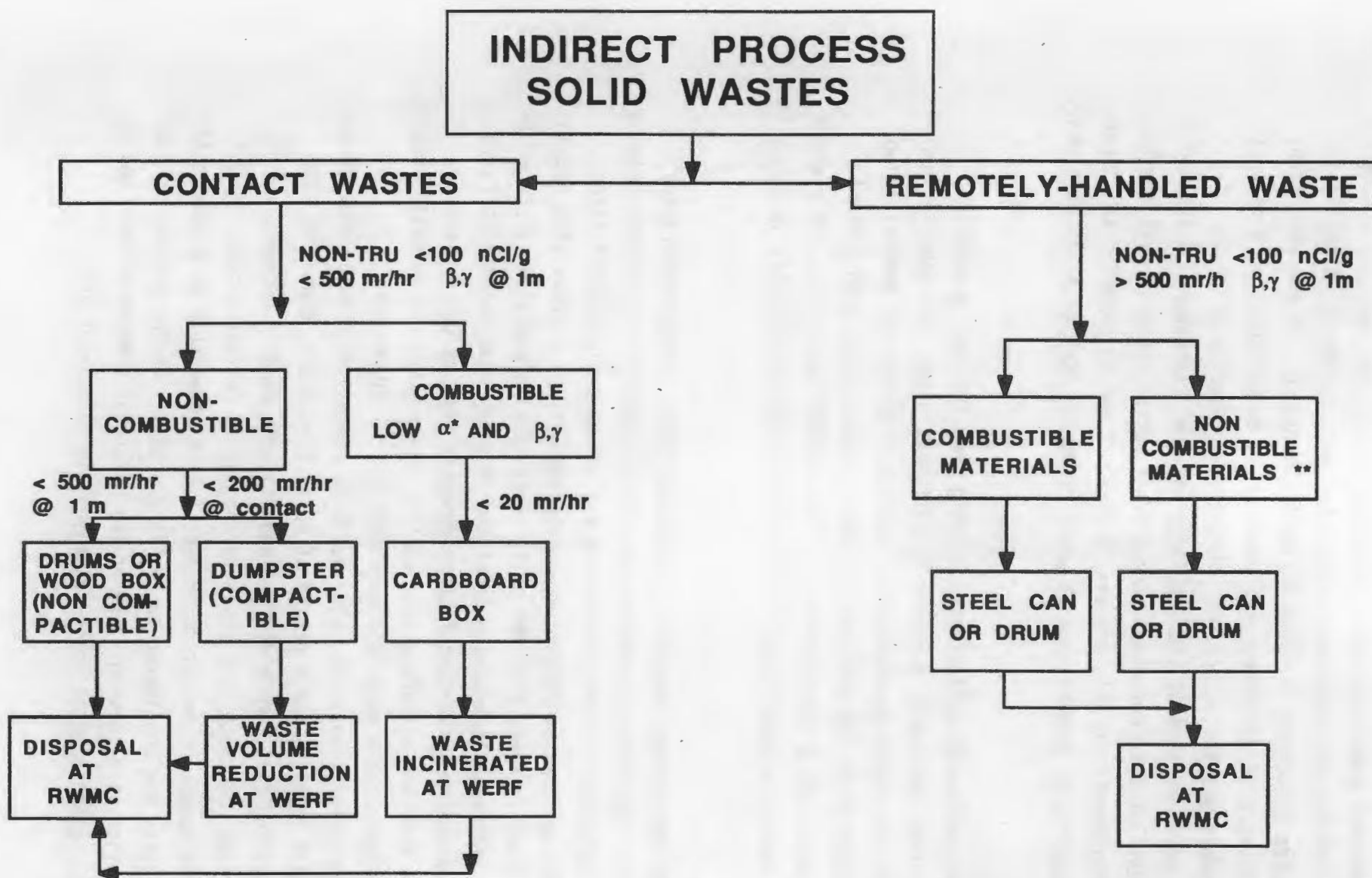
^dWeights could be increased by use of advanced immobilization methods, such as a copper matrix for metal wastes, or siliceous matrix for salts.

^eAllows for periodic cleanout of electrolyrefiner, which is speculative.

of future commercial practice, a demonstration fission gas recovery system has been designed for future installation which involves cryogenic distillation of specific gases contained in the argon cell atmosphere. If and when such fission gas recovery is performed, the gases would be collected at a rate of about one standard gas bottle per year consisting primarily of Kr-85. The collected gas would be sent to the Oak Ridge National Laboratory, which would make the gas available to Government and private sector users through the DOE isotope sales program. In this process, C-14 would not be expected to appear in any process off-gas streams, but it would be in the form of solid carbides, e.g., ZrC.

The variety of solid wastes arising from the fuel processing operations will be handled in a number of different ways. All non-TRU, non-mixed, contact- or remote-handled wastes generated during the demonstration would be disposed of at the RWMC on the INEL, in accordance with current practice for other ANL-W operations, e.g., the HFEF/N hot cells. The present (and assumed future) disposition of this type of radioactive waste is shown in Fig. VI-1.

The non-product materials discharged from the electrorefining operation would represent a different set of characteristics with the cadmium initially being mixed (TRU and Hazardous) and the salt electrolyte being either non-TRU or TRU-contaminated depending upon use of a processing option to strip actinide elements from the salt. Both cadmium and electrolyte would be initially very high in activity level and in decay heat generation rates, owing to the presence of various fission products such as Ce, Sr, and Cs. These streams from the electrorefiner would also contain C-14 as solid, stable carbides. To make these materials more amenable to subsequent treatment/packaging/disposition, they would be placed in existing storage pits in the hot cell facility for a period of up to five years, depending upon prior fuel cooling time, while short-lived isotopes decay. Because, during the decay period, the materials would be subject to further processing (to remove the TRU component and/or to produce a form acceptable at a commercial repository), they are considered to be "in-process". During processing and in-cell retention, the chemical form of the hazardous component would not be changed, i.e., cadmium metal (or metal alloy) is both input and



LEGEND:

- * = LESS THAN 250 DISINTEGRATIONS / MINUTE/ 100 cm²
- ** = INCLUDES S/A HARDWARE
- WERF = WASTE EXPERIMENTAL REDUCTION FACILITY
- RWMC = RADIOACTIVE WASTE MANAGEMENT COMPLEX
- DRUM = DOT 17-C DRUM WITH 90 MIL POLYETHYLENE LINER

FIG. VI-1 DISPOSAL OF VARIOUS TYPES OF INDIRECTLY PRODUCED RADIOACTIVE WASTE (NON- HAZARDOUS, NON-TRU)

output.* The cadmium will be considered "in process" until the transuranic nuclides have been removed or until a final decision has been made that no further TRU processing would be done. Once the cadmium material has been processed to remove the transuranic nuclides or a decision has been made that the cadmium will not be further processed, it will be removed from the argon cell according to RCRA requirements. The pre-processing period is not considered "storage" under RCRA,** and therefore a permit is not being requested for the facility.*** This in-cell storage is not expected to contribute significantly to worker irradiation exposure. Following the decay period, any remote-handled TRU/mixed experimental wastes that DOE directs to WIPP for final disposal would be moved to RSWF, or alternatively to the RWMC for interim storage at the RWMC-Intermediate Level**** Transuranic Storage Facility (ILTSF). Similarly, the contact-handled TRU/mixed waste would be sent to the RWMC Transuranic Storage Area (TSA) or RSWF. WIPP and 10CFR60 criteria will be used as guidance for packaging of high level and remote

*An exception to use of pure cadmium metal or metal alloy is the introduction of cadmium chloride into the electrolyzer to chlorinate the sodium and active fission products. This reduces the cadmium to metal during processing.

**RCRA is the Resource Conservation and Recovery Act of 1976, as amended.

***A conference call was held between representatives of Argonne National Laboratory-West, Department of Energy-Chicago Operations Office, and Wayne Pierre, a Compliance Inspector for the Environmental Protection Agency-Region X, to discuss the issue of when the cadmium in the argon cell would be considered to be "in process" and thus not subject to the provisions of the Resource Conservation and Recovery Act, and when the cadmium would be considered to be waste and subject to the provisions of RCRA. Mr. Pierre was also the EPA contact for the Idaho National Engineering Laboratory (INEL) on RCRA matters. It was agreed to by all parties to the conference call that the cadmium would be considered to be "in process" until the transuranic nuclides had been removed or until a final decision had been made on whether or not to remove them from the cadmium. Once a decision had been made that the cadmium would not be further processed, it would be considered waste and subject to the provisions of RCRA.

****DOE Order 5820.2A specifies that it is the responsibility of the Assistant Secretary for Defense Programs to develop and operate the WIPP to conduct research and development to demonstrate the safe disposal of radioactive waste from both defense activities and programs exempted from regulation by the Nuclear Regulatory Commission. At least certain of the HFEF/S TRU wastes fall into the latter category, and are therefore eligible for disposal at WIPP.

handled TRU waste in the absence of specific criteria for IFR type fuel reprocessing wastes. If the to-be-developed Civilian Repository (CR) packaging criteria are not met, the IFR wastes could be retrieved from any of the interim storage facilities and modified to meet new criteria. This consideration would also apply should WIPP only operate for the five year test period. Eventually, all transuranic wastes will meet Waste Isolation Pilot Plant (WIPP) and/or CR acceptance criteria. The contact-handled TRU wastes are expected to meet acceptance criteria without significant development work. However, some development would be required to meet acceptance criteria with the high activity wastes.

Non-TRU mixed waste with very low surface radiation levels will be sent to the Radioactive Mixed Waste Storage Facility (RMWSF) at the INEL SPERT-IV area, a facility that has interim status under RCRA. The RSWF at ANL-W has interim status and would be Part B permitted (under RCRA) for temporary dry tube storage of IFR process wastes.

There would be other indirect byproduct combinations of TRU, non-TRU, mixed, and non-mixed radioactive materials associated with the process, such as fuel assembly hardware and miscellaneous remote and contact handled wastes. Annual quantity estimates for these wastes are shown in Table VI-3. However, actual categories of many of these wastes cannot be determined until operation commences and waste samples can be analyzed. In addition to these wastes, there would be very small quantities of non-radioactive hazardous wastes that would be disposed of at the Hazardous Waste Storage Facility (HWSF) at the INEL Central Facilities Area, a RCRA interim status facility.

B. Radioactive Liquid Wastes

Sanitary and industrial liquid waste lines are separate and are not routed into the process cells or into areas normally containing loose contamination. Radioactive liquid waste systems will be separate and will have no connection to these sanitary or industrial waste systems.

Radioactive liquids are generated during fuel assembly wash down prior to transfer into the cells and by equipment/facility decontamination; there is no hazardous material component in the fuel assembly wash down

TABLE VI-3
Estimated Quantities of Miscellaneous Wastes and Preliminary Disposition

Waste Descriptor	Typical Contents	Estimated Annual Quantity	Preliminary Disposition			
			If Non-TRU, If TRU	If TRU, Mixed	Mixed	Normal
Very low level Radioactive, Normally ^c Incinerable	<ul style="list-style-type: none"> • Polyethylene • Rags, coveralls • Latex gloves • Wood (150 cu ft/y) 	273 kg/y (600 lb/y) 4.3 cu m/y ^a	TSA ^b	RMWSF	TSA	WERF
Contact Handled Radioactive, Normally ^c Compactable	<ul style="list-style-type: none"> • HEPA filters • Conduit (6000 lb/y) • Ducting 43 cu m/y^a • Non-incinerable combustible material • Shoe covers, gloves • Light duty structural material 	2450 kg/y (1500 cu ft/y)	TSA	RMWSF ^e	TSA	WERF
Contact Handled Radioactive, Non-incinerable Noncompactible	<ul style="list-style-type: none"> • Solid Waste Material <ul style="list-style-type: none"> • Solid metal • Tools • Piping • Solidified liquids • Excess equipment 	910 kg/y (2000 lb/y) 10 cu m/y (350 cu ft/y)	TSA	RMWSF ^e	TSA	RWMC
Non-incinerable Nonradioactive Normal Wastes	<ul style="list-style-type: none"> • Scrap wood • Office wastes 	73 Mt/y N/A ^d (80 t/y) 212 cu m/y (7500 cu ft/y)	N/A	N/A	INEL	Landfill
Remote Handled Radioactive, Process Wastes Non-TRU	<ul style="list-style-type: none"> • Fuel assembly Hardware 	2730 kg/y (6000 lb/y) 1.0 cu m/y (36 cu ft/y)	N/A	N/A	N/A	RWMC
Remote Handled Radioactive, TRU Waste	<ul style="list-style-type: none"> • Filters 4550 kg/y • Misc. combustible 	ILTSF ^f N/A (10,000 lb/y) 3.4 cu m/y (120 cu ft/y)	ILTSF	N/A		
Wastes from small sample analysis at another facility	<ul style="list-style-type: none"> • Hot laboratory waste • Rags, etc. 	5185 kg/y (11400 lb/y) 2.6 cu m/y 91 cu ft/y	ILTSF or TSA	RMWSF	ILTSF or TSA	RWMC

^aEstimate given is before volume reduction.

^bTSA is the Transuranic Storage Area at RWMC.

^cAs used here "normal" refers to wastes that are non-TRU, non-mixed.

^dN/A means not applicable.

^eShielding may be required to meet low surface dose rate acceptance criteria.

^fILTSF is the Intermediate Level Transuranic Storage Facility at RWMC.

stream, but electrorefiner or cathode processor cleaning could produce mixed constituents (Cd bearing). Radioactive liquids would be collected in facility tanks, located in the basement of HFEF/S, and would be subsequently either 1) transferred to the adjacent (existing) Radioactive Liquid Waste Treatment (evaporator) Facility (RLWTF) or 2) transferred to an in-facility SHADE* for evaporation. If significant alpha radioactivity or mixed constituents existed, the in-facility evaporator would be used. The projected amount of liquid processed through this in-facility evaporator would be $75.7 \text{ m}^3/\text{y}$ (20,000 gallons/y). There should be no significant increase over present amounts transferred to the RLWTF unless this facility is used to evaporate some of the liquids scheduled for the HFEF/S in-facility evaporator (i.e., if liquids have low contamination levels). The evaporation of 75.7 m^3 (20,000 gallons) in the in-facility SHADE may result in annual disposal of two SHADE units (containing the residues) as solid waste, probably as waste contaminated with TRU and/or hazardous (Cd) components. If determined to be TRU or mixed waste, the SHADE, after possible interim storage in RSWF or at RMWSF, would eventually be shipped to WIPP or the CR. Otherwise, it would be disposed at RWMC. Hot moist air exhaust from the SHADE would be cooled, then filtered by two testable HEPA filters before release to the environment.

C. Industrial Waste Water

The industrial waste water from the HFEF/S (nonradioactive, nonhazardous) would be pumped to a ditch that drains to a percolation pond northwest and adjacent to the ANL-W perimeter fence. The ditch and percolation pond is an existing system. A hydrogeological description of the industrial waste pond and ditch is given in Appendix H.

D. Sanitary Waste Water

The projected increase in ANL-W employment due to HFEF/S operation is up to 20 persons. Assuming sewage generation is proportional to the total

*The SHADE, which uses hot air to evaporate contaminated liquids, is the primary design option. Alternatives being carried along with the design are pot-type and thin film evaporators with the same basic environmental controls for discharged air/vapors.

number of persons employed at ANL-W, the sanitary waste generation rate will therefore increase approximately 3%. Sanitary waste is directed to sewage lagoons located on the INEL immediately northeast, but adjacent to the ANL-W perimeter fence where biological degradation (aerobic and anaerobic) proceeds continuously and the water is evaporated by solar heating. These lined sewage lagoons are an existing system. There are no sanitary waste water systems added as part of the HFEF/S Modifications Project.

E. Construction Waste

Care will be taken during construction to reduce the volume of the radioactive waste generated. A small layer of contaminated concrete has been removed from the surface of the concrete where the new hot repair facility is located in the basement of the facility. This allows most of the remaining concrete to be disposed as nonradioactive, nonhazardous waste.

The estimated waste volumes produced are small. Table VI-4 shows the estimated amounts and disposition.

F. Decontamination and Decommissioning Wastes

Provisions for ease of decontamination as specified in DOE Order 6430.1A (Ref. VII-1) are being incorporated in areas affected by the HFEF/S modifications. These new provisions will help assure that the facility can be returned to a state where it presents no hazard to the public or to site personnel. Also these requirements provide for surfaces that are easily decontaminated so as to reduce the volume of radioactive waste generated during decommissioning. The presence of the in-facility SHADE evaporator will allow initial wash down of contaminated areas without coincident problems of liquid waste disposal. Equipment will be sectioned and disposed of as mixed/TRU or non-TRU radioactive waste in accordance with the previously described disposition channels.

Decontamination and decommissioning of the facility would be undertaken following the conclusion of the proposed fuel cycle experiments.

TABLE VI-4

Estimated Radioactive and Hazardous Waste Volumes and Disposition for
Major Construction Waste Categories

Waste Category	Estimated Total Volume (m ³)	Disposition of Waste
Radioactive Compactible Waste	<162	WERF ^a
Radioactive Combustible Waste	< 77	WERF
Radioactive Metallic Waste	< 54	WERF
Non-Processible Radioactive Waste	<550	RWMC ^b
Nonradioactive Concrete	<100	CFA ^c Bulk Landfill
Nonradioactive Dirt	<3300	ANL-W Site
"Mixed" Hazardous Waste	< 0.5	RMWSF ^d
Hazardous Waste	< 0.5	HWSF ^e

^aWERF is the INEL Waste Experimental Reduction Facility; after reduction, wastes are stored at RWMC.

^bRWMC is the INEL Radioactive Waste Management Complex.

^cCFA is the INEL Central Facilities Area.

^dRMWSF is the INEL Radioactive Mixed Waste Storage Facility at the SPERT-IV Reactor Area.

^eHWSF is the INEL Hazardous Waste Storage Facility at the INEL Central Facilities Area.

This is expected to occur about the year 2000 unless authorization is extended for processing of other metal fuels.

Decontamination activities are a routine part of the operation of hot cell facilities, and during the 25 year operation of HFEF/S, a range of decontamination work has been done at various times. The largest in scope of these activities include decontamination, on two occasions, of the entire air cell, decontamination of the argon cell following fuel processing operations similar in function to the proposed action, and decontamination and demolition of a contaminated equipment decon chamber and repair area. These prior decontamination efforts give confidence of relatively straightforward methods and that wastes generated can be properly disposed. Decontamination of the modified facility would involve no new techniques, no major new equipment systems, and, most importantly, no new waste streams beyond those encountered in the modifications and in normal operation of the facility.

Contaminated cell equipment would be partially dismantled if needed, then removed through the argon cell transfer lock or the air cell transfer hatch to the decon spray chamber for decontamination. Equipment would then be completely dismantled and parts placed in plastic lined wooden boxes or remote handled waste canisters depending on radiation levels. For argon cell equipment, this is expected to result in some remotely-handled TRU/mixed hazardous waste that would go to the RWMC for shipment to WIPP. For air cell equipment, this would normally result in some non-TRU/non-hazardous remotely-handled waste that would be disposed at RWMC. A rough estimate of the volume of material in boxes or remote handled canisters is given in Table VI-5; this equipment decon/decommissioning might take six months.

Following process equipment disposition, general facility decontamination would begin in the argon cell, expected to be the most contaminated area in the facility. Decontamination would involve first remote vacuuming

TABLE VI-5

Summary of Solid Wastes Produced in HFEF/S Decontamination

Source	Package	Volume	Category	Disposition
Cell equipment	Plastic lined boxes	1200 ft ³	Non-TRU/Non-hazardous contact	RWMC
Cell equipment	Sealed canisters	150 ft ³	Non-TRU/Non-hazardous remote	RWMC
Cell equipment	Sealed canisters	850 ft ³	TRU/Mixed remote	RWMC; to WIPP
Argon cell wash down	SHADE containers	1-2 SHADE	TRU/Mixed Containers ^a	RWMC; to WIPP
Rags, clothing, etc. from argon cell decon	Plastic-lined wood boxes	3000 ft ³	TRU/mixed contact	RWMC; to WIPP
Rags, clothing, etc. from air cell decon	Plastic-lined wood boxes	1500 ft ³	Non-TRU/Non-hazardous contact	WERF for volume reduction; disposal at RWMC
Surface concrete	Plastic-lined wood boxes	200 ft ³	Non-TRU/Non-hazardous contact	RWMC

^a10-20 ft³.

and then wash down (remote and contact*) with high pressure, low volume, water spray. An estimated 37.9 m³ (10,000 gallons) of water would be generated, based on 15.1 m³ (4000 gallons) being generated in the first six months of the previous cleanup. The water would be processed in the facility SHADE evaporator.

Argon cell decontamination was done once before in the period from July 1978 to February 1980. Remote decontamination methods, such as vacuuming and sweeping using manipulators, were first employed, followed by manned entry for scrubbing and spraying. Nine hundred and sixteen person-entries were made, with a total cumulative dose of 99 rad whole body dose (generally low-energy gamma rays) and 599 rad skin dose (generally high-energy beta rays). As the decontamination process proceeded, the average skin and whole body dose rates were reduced from 2850 to 180 mR/hr and from 270 to 20 mR/hr, respectively. In December 1988, a test was conducted on a section of the argon cell floor in which a dilute nitric-acid/phosphoric-acid solution was used to etch the metal that forms a liner of the argon cell. This test reduced the beta and gamma ray radiation by at least another factor of ten and this technique might therefore be considered in any future facility decontamination (the liquid generated would be neutralized and then processed through SHADE evaporators).

The argon cell surface decontamination would generate two main waste streams, the SHADE evaporator barrels containing the solid wastes left behind, and the normal, largely compactible, stream of vacuum filters, rags, protective clothing, etc. These wastes would be expected to be TRU-contaminated and likely mixed-hazardous from the argon cell. As in Section VI.B above, the SHADE product would be shipped to WIPP and the compactible stream would be sent to WIPP as contact-handled waste. This activity would take perhaps a year.**

*Entries into any areas of the facility with known or suspected loose contamination are done with trained personnel in supplied-air suits, or occasionally, in full-face respirators. Radiation exposure of personnel is to the skin or whole-body, with great precautions taken to avoid internal radiation.

**The earlier argon cell decontamination was done on a personnel-available basis, and thus the even more extensive decontamination process discussed might be accelerated.

The air cell surface is painted concrete and decontamination of similar surfaces has been done numerous times resulting in a radiologically clean environment. The general technique is first, remote vacuuming and wipe down, then contact-cleaning by wipe down. In prior years this has reduced the general air cell dose rate to perhaps 30 mR/hr (whole body) and to 100 mR/hr (skin), while generating compactible/combustible waste (generally non-TRU) that is sent to WERF for volume-reduction and then to RWMC for disposal. If a radiologically clean surface is needed, a small portion of the concrete or concrete-paint surface may be removed by grinding or other means of surface removal with appropriate dust control and filtration -- once again, personnel are in supplied air suits. These methods have been remarkably successful in yielding a clean surface. The solid wastes generated, generally non-TRU/non-hazardous (and non-compactible) contact-handled waste, is sent to RWMC for disposal. If TRU, it will eventually be disposed of at WIPP. This concrete cleaning would require 6-12 months, based on prior experience.

By far the bulk of the radiological and/or toxic hazard would be removed with completion of the steps described above and would take 2-2½ years. Nevertheless, there would still be areas within the facility that would require filtered air flow and personnel access controls, such as areas where contaminated piping or ductwork, etc. could only be removed upon complete facility dismantlement. While facility dismantlement is beyond the scope of this assessment, it could be done by relying on the same disposition methods for solid waste streams.

G. Waste Minimization

One of the objectives of the IFR fuel cycle demonstration is to show the commercial feasibility of this concept with the potential for greatly reduced waste volumes. Hence, the demonstration in the modified HFEF/S facility has the minimization of waste volume as a principal operating objective. Waste minimization can be promoted most effectively by avoiding situations that would require the dumping and recharging of the electrorefiner cell, by using administrative controls on electrorefiner charge/discharge operations, and rigorous management attention to the operation of the cell.

Separation of day-to-day operating wastes into combustible, non-combustible, compactable, and non-compactable also helps to reduce final waste volumes (see Fig. VI-1).

Further reduction of waste volumes will be provided by the in-process holding of electrorefiner cathode and anode byproduct materials to permit radioactive decay to more workable levels. This action, which has no deleterious technological impacts, obviates the dilution of these material volumes to achieve levels of heat generation and radioactivity that are acceptable for disposition by established means.

The use of the SHADE (or similar) evaporators would completely eliminate the discharge of radioactive liquid waste and thus would be a major waste volume minimization feature.

VII. ACCIDENTS AND RADIOLOGICAL CONSEQUENCES

All significant processes and operations in HFEF/S would take place behind heavily shielded walls in confined cells. Both the air and the inert atmosphere that would be released from key areas of the facility pass through filters. The quantity of potentially hazardous particles passing through these two stages of HEPA filters would be reduced by a factor of approximately one million. Therefore, it is to be expected that many types of upset conditions or accidents could occur with little effect on the public, the personnel, or the environment.

Evaluation of accident consequences requires consideration of four classes of accidents, distinguished from one another by how likely (or unlikely) they are to occur. The lowest class of accident, called "Anticipated," embraces those events that can reasonably be expected to occur during the life of the facility. The other three classes of accidents only include events that are not expected to occur. "Unlikely" is the classification for events that, for any given year of facility operation, would have a likelihood of occurrence between 1 in 100 and 1 in 10,000. Over the lifetime of the facility, this could be compared to the likelihood of picking a longshot at the racetrack. The other two classifications include

only events whose likelihood of occurrence would be so low that it is difficult to express in terms of everyday human experience. "Extremely Unlikely" is the classification given to events that would have a likelihood of occurrence between 1 in 10,000 and 1 in a million in each year of operation. "Beyond Design Basis" is the classification given to events that have a likelihood of occurrence between 1 in a million and 1 in 100 million during any year of facility operation. This most improbable class of events is included for consideration in order to establish an upper limit for consequences resulting from accidents.

For purposes of this environmental assessment, only those accidents that have the worst consequences for each classification are discussed. It is believed that all other accidents within any particular classification would have lesser consequences.

A. Design Basis Accidents

During planning of the HFEF/S modifications many potential accident scenarios were analyzed. Preliminary analyses were performed without credit for mitigating features to establish the worst-case consequences and therefore determine the need for safety-class components (i.e., for mitigation). In this discussion, mitigating features are assumed to be present in accordance with DOE-ANL agreements on design and operation of systems to be installed in HFEF/S. It has been necessary in most cases to extrapolate the radiological consequences to be consistent with the latest decisions regarding the amount of material that is "at risk" of becoming involved in an accident. A list of analyses of the "bounding" accidents and their consequences is given in Table VII-1; credit has been taken for planned mitigating features. Estimated worker doses are reported assuming a 15 minute evacuation time that has been verified as conservative by many practice evacuations of the ANL-W site. Worker doses are evaluated at the on-site staging area, 737 in Fig. II-3, where personnel are loaded onto evacuation buses during an emergency

TABLE VII-1

Summary of Bounding Design Basis Accidents
from Preliminary Analyses

Postulated Accident	Radiological Dose (rem, eff. WB)* INEL Bdry Worker		Mitigating Features Credited ^b	Analysis Conservatisms
Release of all argon cell atmosphere ^c .	4.5x10 ⁻⁶ 4.7x10 ⁻⁴ (s)	5.0x10 ⁻⁴ 5.5x10 ⁻² (s)	Argon Cell Exhaust System ^a	An actual release would most likely be a partial re- lease--no credit taken here. Also no credit taken for elevated stack release point.
Fuel assembly meltdown in Air Cell Storage Pit.	1x10 ⁻⁷	1.1x10 ⁻⁵	Air Cell Exhaust System ^a	No credit taken for operator action to miti- gate. Also, no credit taken for elevated stack release point.
Waste box burns in basement.	2.3x10 ⁻⁵	3x10 ⁻³	None	Assumes filters in air cell ex- haust system are immediately plugged. No credit taken for on-site fire dept. or INEL fire dept., or for wet-sprinkler fire suppression system to mitigate.
Metal fire due to small breach in argon cell ^e .	9x10 ⁻⁵	--- ^d	Argon Cell Exhaust System ^a	No credit taken for operator action to miti- gate or for ele- vated stack re- lease point.
Metal fire due to large breach in argon cell ^{e,f} .	1.1x10 ⁻⁴	1.6x10 ⁻³	Argon Cell Exhaust System ^a	No credit taken for operator action to miti- gate or for ele- vated stack re- lease point.

TABLE VII-1 (cont.)

Postulated Accident	Radiological Dose (rem, eff. WB)*		Mitigating Features Credited ^b	Analysis Conservatism
	INEL Bdry	Worker		
Release of fission gas ^g .	3.7x10 ⁻⁵ 3.9x10 ⁻³ (s)	4.2x10 ⁻³ 0.46(s)	None	No credit taken for elevated stack release point
Waste can spill or meltdown ^h .	2.5x10 ⁻⁵	3x10 ⁻³	Air Cell Exhaust System ^a	Uses metal fire release fractions. No credit taken for operator action to mitigate, or for elevated stack re-point

* Legend: s = skin dose
WB = whole body
eff. = effective equivalent dose

^aThese features include two stages of in-place testable HEPA filters.

^bMost accidents could also be mitigated by operator action.

^cDose linearly-extrapolated from original cell Kr-85 loading estimate to most recent estimate of 1800 Ci; now based on chopping of two batches (5 high burnup fuel assemblies per batch) in every 2-week period. Note that this is a bounding event, and that a real event would likely be only a partial release of cell atmosphere.

^dDose unevaluated during preliminary analysis, but will likely not exceed the site boundary dose by more than a factor of 15.

^eLinearly extrapolated from preliminary estimates to most recent 65 Kg cell heavy metal combustible loading; reanalysis to be performed for Final Safety Analysis Report. No credit taken here for seismic-hardened individual process confinements (a defense-in-depth measure).

^fBreach size within capability of Argon Cell Exhaust System to accommodate (less than one square foot).

^gDose linearly extrapolated from preliminary analysis processing load basis of 60 fuel assemblies per year to peak load estimate of 90 fuel assemblies per year (approximately 15000 Ci of Kr-85).

^hDose linearly extrapolated from preliminary analysis estimates to most recent "bounding" estimate of 1000 Ci Pu-239 equivalent and fission product heating of 1000 W in a single waste can.

condition. Doses received by the public are evaluated at the nearest INEL site boundary, assuming a two-hour residence time from the onset of the accident, even though that boundary is a through highway and there are no nearby residents. For the metal fire and fuel assembly meltdown accidents described herein, credit is taken for the effect of the radiation plume transport time in reducing the time that the receptor is exposed to the radiation cloud.

Techniques established in NRC Regulatory Guides 1.145 and 4.2* (Ref. VII-1) have been used to evaluate the dispersion of radioactivity. All releases are assumed to be at ground level even though the stack exhaust system would be operational in most cases. Source terms are shown in Appendix B for one EBR-II fuel assembly (4.42 kg heavy metal). All projected doses will be well below those allowed by DOE guidelines for accident conditions (Ref. VII-2 and -3). According to Ref. VII-3, these limits are a maximum of 0.5 Rem (whole body) for anticipated events, 2.5 Rem (whole body) for unlikely events**, and 25 Rem (whole body) for extremely unlikely events.*** Reference VII-2 further requires that accident doses be maintained As Low As Reasonably Achievable (ALARA).

Severe flooding at the HFEF/S Facility due to rain storm or high water levels from off-site sources (i.e., in a manner that would flood the process cells) is clearly incredible because of the low site annual precipitation and because ANL-W is situated well above the flood-stage level of any stream or reservoir in the near vicinity.

*Regulatory Guide 1.145 techniques were used to establish the 50th percentile (i.e., median) meteorological dispersion as specified in Regulatory Guide 4.2. This required a correction factor to be applied to dose estimates from preliminary analysis (which used different meteorological assumptions).

**Actual limit is stated as "small fraction (i.e. 10%) of condition IV (extremely unlikely) guidelines".

***Limits are also stated for other organs as 300 rem to the thyroid from iodine exposure, 300 rem to the bone surface, 75 rem to the lung, or 75 rem to any other organ.

However, three credible sources for some degree of basement flooding have been identified. First, because there are numerous water pipes in the facility, some leakage and local flooding may occur. The components of the argon cell exhaust system located below the operating floor level in HFEF/S will be designed to operate in a flooded condition.

The two ANL-W site water storage tanks where seismic deficiencies have been noted are a second potential source of basement flooding. These tanks, of 757 and 1514 cubic meters (200,000 and 400,000 gallon) capacity, are located about 100 m (330 ft) north of HFEF/S. Steps are being taken to increase their seismic resistance.

The third potential source for facility flooding is activation (due to fire or malfunction) of one or more sprinkler heads in the HFEF/S fire protection system. This would be expected to cause some local flooding, but because of the associated water-flow alarm system and quick response from the ANL-W fire station and from HFEF/S personnel, the degree of flooding from this source would be minor.

Therefore, credible flooding events are considered to be both minor in nature and of insignificant environmental, health, or safety impact.

The effect of high winds will be minimal since analyses indicate that even the outer building structural shell will, with minor modifications, survive the design-basis wind, and the heavily-shielded cells are well-protected by their basic design.

The new backup diesel-generator power system will be housed in a new building that will be designed to be resistant to both seismic and high-wind forces. The backup diesel generator power sources and distribution system (to critical items) will be similarly designed. Therefore the continuity of power to the argon cell exhaust system, after the occurrence of design basis natural phenomena, is ensured.

In order to judge the risk (defined as probability x consequence), accidents have been assigned to likelihood categories, based on the number of

independent events required for initiation of the accident and engineering judgments regarding the relative likelihood of each event. DOE safety guidance (Ref. VII-1) uses the classifications of anticipated, unlikely, extremely unlikely, and beyond-design-basis for abnormal events, herein defined in accordance with the following:

Anticipated Events: Incidents or events of moderate frequency which may occur once or more during the life of a facility (e.g., minor incidents and upsets). These events have a likelihood of occurrence in the range greater than 10^{-2} per year.

Unlikely Events: Incidents or events that are not expected, but which may occur during the lifetime of a facility (e.g., more severe incidents). These events have a likelihood of occurrence in the range of 10^{-2} to 10^{-4} per year.

Extremely Unlikely Events: Events that are limiting faults and are not expected to occur during the life of a facility but are postulated because their consequences would include the potential for the release of significant amounts of radioactive material and because they represent upper bounds on failures or accidents with a likelihood of occurrence sufficiently high to require consideration in design. These events have a likelihood of occurrence in the range of 10^{-4} to 10^{-6} per year.

Beyond design Basis Events: Events of extremely low probability of occurrence or non-mechanistic hypothetical events. These events have a likelihood less than 10^{-6} per year. These accidents are discussed in Section VII.B, and, in this document, are referred to as "Beyond-Design-Basis Accidents" (Beyond-DBA).

For this assessment, the accidents shown in Table VII-1 have been assigned to these probability categories as shown in the following table. Justification for these assignments is given in Appendix C.

<u>Anticipated</u> <u>(>10⁻² per year)</u>	<u>Unlikely</u> <u>(10⁻²-10⁻⁴ per year)</u>	<u>Extremely Unlikely</u> <u>(10⁻⁴-10⁻⁶ per year)</u>
•Release of all argon cell atmosphere (Note: an actual accident would likely be only a partial release)	•Waste box burns in basement	•Metal fire due to large breach ^a in argon cell
•Release of fission gas	•Metal fire due to small breach in argon cell	
•Waste can spill ^b or meltdown	•Fuel assembly meltdown in air cell storage pit	

^aSee footnote regarding assumed size of large breach as discussed under the VII.A.1 Metal Fire Accident.

^bThe HFEF/S Modifications Project is investigating preventive features to relegate this accident to the unlikely category (or beyond).

Examples of accident scenarios are given below for the metal fire due to large breach in the argon cell, accidental release of fission gas, release of all argon cell atmosphere, and fuel assembly meltdown in air cell storage pit. Additional details can be found in Appendices B and C.

1. Metal Fire Due to Large Breach in Argon Cell (extremely unlikely category; 10⁻⁴ to 10⁻⁶ per year)

The metal fire accident, resulting from a large breach* in the argon cell boundary, assumes that a substantial amount of heavy metal (Pu-U) fuel, with fission products produced by 18%** heavy metal in-reactor burnup (and 110 d cooling time) is rapidly oxidized in the argon cell. The preliminary analysis was actually performed for 10 kg of heavy metal and the

*The size of large breach in this section is assumed to be within the capability of the argon cell exhaust system to maintain capture velocities across the breach area and thus prevent backward flow of contamination. It is not the 1.8 m (6 ft) diameter breach described in the next section for beyond-design-basis accidents.

**18% heavy metal burnup is assumed in accident cases, 10% burnup is assumed for normal release calculations. 110 d cooling time corresponds approximately to maximum allowed heat load for a single fuel assembly in HFEF/S (i.e., 500W) at the higher (18%) burnup.

results have been extrapolated to 65 kg for this assessment. More detailed analyses are planned for the Final Safety Analysis Report. Credit has been taken for HEPA filtration by the argon cell exhaust system, which is to be designed to accommodate seismic forces and the airborne products generated by the cell metal fire (i.e., filter before release), regardless of any other protection features such as the seismically hardened process confinements. Details of the metal fire accident parameters are given below.

- Fuel irradiation history and cooling time
 - Irradiation in reactor, 1076 d at 0.7 MW power
 - Fuel Cooling time, 110 d
- Composition of fuel
 - Uranium-Plutonium-Zirconium metal alloy
(see Appendix A for details)
- Isotopic composition of fuel after irradiation - calculated using ORIGEN computer code - see Appendix B.
- Fraction of material in fuel airborne from fire
 - Cesium, 0.35 (Ref. VII-6)
 - Iodine, not applicable; negligible inventory of I-131 at the fuel cooling times anticipated. I-129 inventory is inconsequential compared to other isotopes.
 - Plutonium and uranium, 0.0005*
 - Solid fission products, 0.0005**
- Fraction plated out and as fallout in argon cell, or in exhaust system
 - 1/2 (c.f., Ref. VII-8)

*Based on the metal fire release studies of Mishima and Schwendiman (Ref. VII-4).

**Solid fission products assumed to have same release fraction as heavy metal, a frequent assumption in safety analyses (c.f., Ref. V-13).

- Elevation of release (assumed)
 - ground level
- Argon cell exhaust system HEPA filter particulate attenuation
 - 1×10^{-2} per stage*, 1×10^{-4} overall (2 series stages), for accident modeling
- Atmospheric modeling
 - in accordance with U.S. NRC Regulatory Guides 1.145 and 4.2
 - Meteorology based on 5-year accumulation of on-site (ANL-W) data
 - Meteorological dispersion parameter (x/Q)
 - on-site personnel, $5.2 \times 10^{-4} \text{ s/m}^3$
 - site boundary, $4.5 \times 10^{-6} \text{ s/m}^3$
 - Windspeed toward receptor
 - toward on-site evacuation area, 3.5 m/s
 - toward site boundary, 12.5 m/s
- Distances to receptor for dose evaluations
 - nearest site boundary location, 5000 m
 - on-site personnel, 230 m (location of site personnel assembly area for loading onto evacuation transportation buses)
- Plume transport times to receptor
 - Consistent with windspeed and distance to receptor

*This attenuation represents a degraded efficiency compared to DOE-AL recommended accident values of 1×10^{-3} for first stage and 2×10^{-3} for second stage (Ref V-13). This helps to account for any degradation that might occur due to absence of specific fire protection features upstream of the filters.

- Receptor residence times
 - at nearest site boundary location, 2 h - from onset of accident
 - on-site personnel, 15 min

2. Release of Fission Gas (anticipated category; $>10^{-2}$ per year)

A release of fission gas from the fission gas recovery system is one type of fission gas release accident. A breach might occur in the piping or valving used to connect a collection bottle to the fission gas purification system. The accident analysis assumes that the contents of the bottle are near the (planned) administrative limit of one years' processing load of Kr-85 from peak-load processing of 90 subassemblies (15,000 Ci of Kr-85) at the time of the release. Meteorological and other applicable parameters are the same for this analysis as used in the metal fire analysis described previously. The release to the atmosphere is assumed to be 100% of the bottle's contents.

This accident has greater radiological consequences than other accidents in the same likelihood-of-occurrence category, and even greater than most accidents that are less likely. This greater radiological consequence results because most other accidents primarily involve particulate releases, which are effectively reduced by HEPA filtration. Although there is no such reduction for the gaseous releases in this accident, the radiological dose is nevertheless small because the major fission gas involved (primarily Kr-85) have very low radiotoxicity.

3. Release of All Argon Cell Atmosphere (anticipated category; $>10^{-2}$ per year)

The release of all cell atmosphere (via the argon cell exhaust and pressure relief system) is another type of fission gas release accident. The release could be caused by overpressurization of the cell (i.e., possibly due to a failure of a pressurized cell atmosphere supply system or due to loss-of-cell-cooling), because of inattentive operation of a transfer lock vacuum pump, or by inadvertent activation of the argon cell exhaust system (or

misoperation of the associated control valves). Other possibilities may also exist. An actual accident would likely be only a partial release of the cell atmosphere. However, for conservatism a "bounding" event is assumed in which all the atmosphere is released. Accident meteorological and other applicable parameters are the same as those assumed for the metal fire analysis.

Particulates in the cell atmosphere will be kept at very low levels by the $4.7 \text{ m}^3/\text{s}$ (10000 cfm) recirculating cooling system, which replaces the cell volume (186 m^3 , or 66000 ft^3) every 400 seconds and which has installed HEPA filters. Also, upon release from the cell, further filtration is done in the argon cell exhaust system. Therefore particulate release is not an issue for this accident. However the argon cell atmosphere will contain (primarily) Kr-85, released to the cell during processing. It is assumed that a batch of high burnup fuel (5 assemblies with 18% heavy metal burnup) has been chopped every two weeks prior to the accident, and that a new batch has just been chopped. (These are very conservative assumptions.) It is also assumed that, between batches, the argon cell purge rate operates at $2.4 \times 10^{-3} \text{ m}^3/\text{s}$ (5 cfm) to control nitrogen in the cell atmosphere and to reduce the cell Kr-85 inventory. This corresponds to 1800 Ci of Kr-85 in the cell atmosphere.

4. Fuel Assembly Meltdown in Air Cell Storage Pit (unlikely category; 10^{-2} to 10^{-4} per year)

The accident described as "fuel assembly meltdown in air cell storage pit" assumes the operator inadvertently places a "hot" metal-fueled assembly into a floor storage pit in the air cell. All fuel assemblies awaiting processing are stored above floor* (in racks) to assure passive cooling if forced cooling is lost. One irradiated (18% heavy metal burnup**)

*This will not preclude storage in pits if it can be demonstrated that fuel clad failure will not occur at the maximum allowed decay heat under absence of forced cooling.

**18% heavy metal burnup is assumed for accident cases, 10% burnup (a more likely average) is assumed for normal release calculations, a cooling time of 110 d corresponds approximately to the maximum allowed heat load (i.e., 500 W) for a single fuel assembly that has been irradiated to 18% heavy metal burnup at a continuous power level of 0.7 MW.

fuel assembly is assumed to be placed into a storage pit, together with three adjacent, newly constructed, fuel assemblies (4.42 kg heavy metal each; see Appendix B), causing also meltdown of these "cold" fuel assemblies.* The accident assumptions are generally identical to the argon cell metal fire except for the change in source term. Because of the depth of the storage pit, its cover, and the circuitous route of the aerosol, a local confinement factor of 0.01 is applied for fallout and plateout in addition to the factors applied for the argon cell metal fire. This factor is considered conservative and is based on work sponsored by the Atomic Energy Commission (Ref. VII-5), and the subsequent analyses that extrapolated this work to the HFEF/S storage pits (Ref. VII-6).

During preliminary analysis, no attempt was made to demonstrate that this scenario is feasible; that is, that a "hot" fuel assembly would actually melt down and involve adjacent fuel assemblies. Further analyses and experiments might show this scenario to be incredible. In this accident, credit is taken for the air cell exhaust system, which is similar to the argon cell exhaust system in that it employs redundancy of important components. It also has two stages of (in-place) DOP-testable HEPA filters.

B. Beyond-Design-Basis-Accidents (10^{-6} to 10^{-8} per year)

Two beyond-design-basis accidents have been evaluated for the modified HFEF/S. These accidents and their consequences are summarized in Table VII-2. The bounding accident is a metal fire occurring simultaneously with a very large hole in the argon cell confinement. The other accident, a

*Four fuel assemblies are the maximum number that are allowed to be placed in a pit simultaneously.

TABLE VII-2

Summary of Beyond-Design-Basis Accidents from Preliminary Analyses^C
(10^{-6} to 10^{-8} per year)

Postulated Accident	Radiological Dose ^a (rem, eff. WB)		Mitigating Features Credited	Other Available Features Not Credited	Basic Assumptions
	INEL Bdry	Worker			
Criticality	0.0012	0.15	HEPA filters in argon cell exhaust system.		All energy assumed to be transferred into heating and vaporization of fuel.
Metal fire due to large [1.8 m (6 ft)] dia. breach in argon cell - unfiltered release	1.1	15.6	None	Argon Cell Exhaust system (HEPA filtration) ^b	Assumes accident caused by large breach in cell boundary (6 ft diameter)

^aInhalation dose.

^bThe extent to which HEPA filtration would be effective for a 6 ft diameter breach is unknown at this time. This size of breach would be beyond the design capability of the argon cell exhaust system.

^cExtrapolations and corrections are made for increased metal fire loadings and revised meteorological dispersion parameters since preliminary analyses were done.

plutonium criticality event, has minor health and environmental consequences by comparison.

In the metal fire accident, the fire in the hot process metal is assumed to start after sufficient oxygen enters through the large (1.8 m [6 ft]) diameter breach. Although there are no data to suggest the possibility of an earthquake of sufficient magnitude and proximity to damage the cell that severely, such an event has been postulated as one that could break a large hole in the cell. The maximum amount of heavy metal in process at any one time, 65 kg, is assumed to be involved in the fire. No credit is taken for confinement of the heavy metal in process equipment, even though the

process equipment is being designed to survive a massive earthquake with the confinement boundary intact. The large breach in the cell would be beyond the designed capability of the argon cell exhaust system, so that the subsequent ground-level release might not be completely routed through and attenuated by the HEPA filters. In other respects, this metal fire accident has been analyzed under the same assumptions that were used in the analysis of the design-basis large-breach, metal fire that was mitigated by the argon cell exhaust system and its HEPA filters.

This accident is considered to be the bounding accident event, because no other accident, even one with a lower probability of occurrence, would have more severe consequences than unfiltered releases from a fire involving all heavy metal in the argon cell process stream.

A criticality accident has also been analyzed as a beyond-design-basis event. The HFEF/S Modifications Project has taken as a design goal that a safe margin of subcriticality shall exist during all normal and credible abnormal conditions. Process equipment has been designed with features that, together with strict administrative controls, will help assure that this goal is met.

In the preliminary analysis, specific assumptions were made for the criticality accident. U-Pu-Zr ternary alloy fuel was assumed to go super-prompt critical in the casting furnace in the argon cell. The total yield was 10^{18} fissions (Ref. VII-7): all energy went into heating and vaporizing the already-molten fuel alloy; there was immediate uniform transfer of heat and mixing of aerosol with the cell atmosphere. The resultant cell overpressure of less than 0.9 psi was relieved through the exhaust system. The releases were attenuated by the HEPA filters. Uranium criticality is not considered because the additional mass and volume required for such an event would require that at least one or two additional levels of mistakes were made. This means that a uranium criticality would be about two orders of more unlikely than a plutonium criticality.

A review (Ref. VII-9) of the eight known criticality accidents shows that there has never been an accident in a metal process stream, which is the general type of processing to be done in HFEF/S. Each accident

occurred in some stage of aqueous (PUREX) reprocessing. Because reprocessing in the U.S. has essentially been limited to the defense programs, the quantity of enriched uranium and plutonium that has been handled in metal form is not substantially less than that reprocessed by PUREX. Nevertheless, potential criticality accidents will receive substantial additional evaluation prior to issuance of the Final Safety Analysis Report.

C. Transportation Accidents

The proposed HFEF/S modifications will significantly reduce the probability of an over-the-road transportation accident involving fissile material with high heat source, since essentially all the irradiated fuel material would remain in the enclosed path between the HFEF/S processing facility and the EBR-II. (Presently, irradiated fuel is transported over a public highway to the ICPP for processing.)

D. Co-location Issues

There are only two fundamental safety issues associated with co-location of the EBR-II and HFEF/S facilities. One issue is the possibility of an accident in one facility leading to an accident in the other facility. The other issue is whether the facilities can be safely shut down and evacuated to protect personnel.

No accidents in either facility have been identified that would lead to an accident in the adjacent facility. Further, there are no accidents identified in either facility that would prevent the safe shutdown and subsequent safe operation of protective equipment in the other facility. In addition, site personnel are protected from the effects of an accident by established emergency procedures, and many preventive or protective features of the facilities. If an analysis predicts that an accident would give an unacceptable radiological dose, then a preventive or mitigative feature would be installed.

Due to its natural safety features, the reactor is particularly well-designed to allow for rapid evacuation of all personnel. The basic

emergency procedures that are required in order to evacuate the EBR-II plant consist of the following:

- Insert the reactor control rods, and perform partial building isolation.
- Turn off the primary and secondary system coolant pumps.
- Shut main steam stop.
- Turn off feedwater pump.
- Turn on primary system sodium tank heaters.

Because of the simplicity of these actions the reactor can be placed in a safe shutdown mode in a very short period of time. Even these simple actions are more than would be required to protect personnel, but they are needed to assure protection of plant equipment.

With regard to the effect of a reactor accident on HFEF/S, the HFEF/S Modifications Project has adopted a formal safety design criterion that requires the equipment modifications to be designed such that, if an HFEF/S evacuation is required, there will be no abnormal release of radioactivity.

The HFEF/S facility can remain in a safe shutdown condition after the facility has been evacuated. The only EBR-II reactor accident identified that might significantly affect the safe (post-evacuation) operation of HFEF/S confinement systems would be a major breach in the EBR-II secondary sodium cooling system and subsequent sodium fire outside the reactor containment. A severe earthquake has been postulated as the initiator of this event. However, the secondary cooling system has been evaluated by an independent seismic consultant and was judged to be sufficiently flexible and ductile so as to not be a significant contributor to seismic risk.

VIII. REASONABLE ALTERNATIVES AND THEIR ENVIRONMENTAL CONSEQUENCES

Two alternatives to the proposed action are considered in this section. The first is to take no action, that is to continue the present practice of EBR-II fuel supply and to continue IFR fuel cycle development in a non-integrated way in separate, small facilities. However, the past method of reprocessing EBR-II fuel assemblies at the ICPP is no longer an option. A new

process line would have to be developed, or the fuel assemblies would have to be stored indefinitely. The second alternative is to accomplish the objectives of an integrated system test in some other facility at some other location.

A. No Action

The first alternative to the proposed action would be to take no action and to continue the present practice of fuel cycle experimentation being done at smaller scales and at diverse locations. The no action alternative would continue to fabricate fuel for EBR-II at existing facilities at the ANL-W site and continue reprocessing EBR-II fuel at ICPP or to store spent EBR-II fuel indefinitely, depending on its type. This would only be a no-action alternative for ANL-W, because of a new process line would have to be developed at ICPP for EBR-II fuel.

EBR-II operation will continue regardless of the fuel cycle alternatives described for the proposed action. The EBR-II core is now being gradually converted to the specific metal alloy fuels of the IFR program -- uranium-zirconium and uranium-plutonium-zirconium. This core conversion, which is a replacement of an earlier metal alloy fuel, will continue regardless of the fuel cycle outcome.

EBR-II, like all reactors, must be supplied periodically with fresh fuel to maintain operation. There are about 90 fuel assemblies in EBR-II at any one time, and as a rough average, about 60 of these fuel assemblies will be discharged in a year of reactor operation and replaced with fresh fuel.

The fuel assemblies for the reactor consists of two types, "driver" and experimental assemblies. Driver assemblies generally comprise 80-90% of the reactor loading and are the fresh feed assemblies -- they are the standard workhorse fuel assemblies with design parameters changed very infrequently.*

*In the twenty-four years that EBR-II has operated, there have been only five driver assembly types, and a sixth is now being contemplated.

The remaining experimental assemblies, as their name implies, are one-of-a-kind or few-of-a-kind assemblies that are in the reactor to address specific R&D issues.

Driver assemblies are presently fabricated on the ANL-W site within the FMF. Experimental fuel assemblies are generally fabricated at either the FMF, or if plutonium is contained within the fuel elements of the fuel assembly, at the small EFL on the ANL-W site. Far more often in the past than is the case today, experimental fuel assemblies, or elements that are to go into assembly, were fabricated elsewhere (e.g., Los Alamos National Laboratory or the Hanford Engineering Development Laboratory) and were then transported to the ANL-W site. In all cases, the uranium and/or plutonium materials that are used in this fuel manufacturing come from the national stockpile. They are removed as needed and are transported to the ANL-W site.

Previously, driver fuel assemblies that were discharged from EBR-II (i.e., those that make up 80-90% of the total) were taken to either HFEF/S or HFEF/N where they are dismantled. This involved removing (in a remote operation) the hexagonally shaped duct and recovering the 60-90 fuel elements contained inside. These elements (metal fuel slugs still encapsulated in sealed cladding tubes) were placed into canisters, up to twelve elements in a canister. The canisters were then placed in a shipping cask, and transported to the ICPP over about 12 miles of DOE facility access road and 12 miles of U.S. Highway 20. From 60 to 100 of these spent fuel shipments were made each year.

At ICPP, the canisters were placed in water storage basins. After a sufficient accumulation, they were processed. The recovered uranium, the product of the PUREX technology in use at ICPP, was returned to the national inventory. Fission products and any plutonium that was bred into the uranium driver fuel during its core residence, were calcined at ICPP and are presently stored in underground tanks.

Experimental fuel assemblies that are presently discharged from EBR-II are disposed of in a variety of ways. All go through some measurement program and, in general, they are stored indefinitely at various sites.

Occasionally some of these elements or fuel assemblies have been processed at DOE facilities outside Idaho for recovery of materials.

B. Tests in Another, Unspecified Facility

The second alternative would accomplish the programmatic objectives of an integrated system test in some other facility at some other location. This alternative is not favored from a programmatic perspective because it is excessively costly when compared to the proposed action of modifying an existing facility.

From an environmental perspective, there are disadvantages compared to the proposed action. First, the reduction in the transport of spent and reprocessed fuel found in the proposed action would be lost. Second, although installing the process in another facility would result in the same releases -- because the same technology would be used -- the benefits of a distant site boundary present at the INEL would likely be lost. Finally, if a new facility were to be constructed, it would bring about the additional environmental impacts associated with construction.

IX. APPLICABLE REQUIREMENTS

The HFEF/S modifications will be conducted in accordance with the applicable portions of DOE General Design Criteria Manual, DOE Order 6430.1A (Ref. VII-1). The following environmental requirements will be complied with (but will not necessarily be limited to) during HFEF/S modification and subsequent operation: 1) the National Environmental Policy Act (NEPA), 2) the Resource Conservation and Recovery Act (RCRA), 3) the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), including the Superfund Amendments and Reauthorization Act (SARA), 4) the Clean Air Act, 5) the Clean Water Act, 6) the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), 7) the Toxic Substances Control Act (TSCA), 8) the Safe Drinking Water Act (SDWA), and 9) the EPA regulations on Underground Storage Tanks (UST).

ANL-W will comply with all applicable environmental regulations of the State of Idaho.

Once in operation, the HFEF/S program will be conducted in accordance with DOE Orders related to security, safety and protection of the environment, as well as with the ANL-W Health and Safety Manual, which is a practical implementation of DOE Orders and State and Federal Regulations.

The approved State of Idaho PSD Air Quality (Ref V-3) permit to construct and the approved 40CFR61.07 NESHAP application (Ref. V-2) place limits on operations related to implementation of best available control technology for airborne cadmium and radioactive releases to the environment. The NESHAP document requires that two stages of DOP-tested HEPA filtration be provided for ventilation exhaust from normally contaminated areas and one DOP-tested HEPA filter stage for exhaust from clean areas. The PSD permit sets required testing frequency and replacement criteria.

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APPENDIX A

ANALYSIS ASSUMPTIONS FOR NORMAL OPERATIONS UNDER THE PROPOSED ACTION

Input/output data for/from isotopic buildup/depletion calculations, AIRDOS-RADRSK dose calculations, and radioactive release calculations are given in this appendix.

A.1 Fuel Assembly Description (prior to irradiation)

1. Heavy metal content - 4420 g,
Fuel Composition (weight fractions)
U - 0.71
Pu - 0.19^a
Zr - 0.10
2. Initial uranium isotopics (weight fraction)
U-234 -- 0.0059
U-235 -- 0.60
U-236 -- 0.0033
U-238 -- 0.39
3. Initial plutonium isotopics (weight fraction)
Pu-238 -- 0.00065
Pu-239 -- 0.8077
Pu-240 -- 0.1749
Pu-241 -- 0.0128
Pu-242 -- 0.0039
4. Total Cladding weight -- 43 g total per pin, 61 pins per fuel assembly.
5. Cladding composition (weight fraction, HT-9 stainless steel)

Fe	Cr	Ni	Mo
0.8523	0.1150	0.005	0.010
W	V	Si	
0.005	0.003	0.0025	
Mn	C	N	
0.005	0.002	0.0002	

^aRecent fuel specifications for advanced modular liquid metal reactors may require irradiation and processing of fuel with up to 28 weight percent plutonium. However, because the basis for estimates is that all fuel assemblies are plutonium-bearing, and only 20% or less are expected to actually contain plutonium, the amount of plutonium handled in the facility has been conservatively bounded.

A.2 Basic Data - Normal operations, airborne release calculations

Five year averaged ANL-W site Meteorological Parameters from AIRDOS calculations (see Table A-1)

TABLE A-1

Frequencies of Wind Directions and True-Averaged Wind Speeds at ANL-W
For 75 m Elevation

Wind Toward*	Frequency	Wind Speeds for Each Stability Class (Meters/Second)						
		A	B	C	D	E	F	G
1 (N)	0.098	5.41	5.23	5.74	9.84	9.63	4.54	0.00
2	0.036	5.04	4.76	5.41	8.39	8.73	4.34	0.00
3 (NW)	0.022	2.70	5.22	4.64	7.35	8.82	3.74	0.00
4	0.017	2.59	4.18	5.77	6.93	9.75	3.84	0.00
5 (W)	0.015	3.24	3.87	4.74	4.00	6.51	3.74	0.00
6	0.036	5.28	4.32	5.05	6.89	9.21	4.79	0.00
7 (SW)	0.110	5.18	4.80	5.06	7.14	9.63	5.10	0.00
8	0.100	5.02	4.78	4.91	7.85	10.46	4.59	0.00
9 (S)	0.055	4.47	5.16	5.59	7.18	10.69	4.33	0.00
10	0.045	3.89	4.36	4.74	6.28	9.12	4.11	0.00
11 (SE)	0.036	3.60	4.01	3.97	6.03	8.68	3.47	0.00
12	0.028	3.70	3.82	3.67	3.91	8.95	3.28	0.00
13 (E)	0.032	3.19	4.29	4.42	4.71	9.35	3.88	0.00
14	0.099	6.39	6.66	7.59	13.89	11.19	4.82	0.00
15 (NE)	0.145	7.27	7.92	8.73	15.16	11.23	4.82	0.00
16	0.118	6.44	7.37	8.34	13.19	10.94	5.01	0.00

*Wind directions are numbered counterclockwise starting at 1 for due north.

A.3 Radioisotope Inventories and Estimated Facility Particulate Releases (See Table A-2)

TABLE A-2

Estimated Combined^a Annual Particulate Releases from
Operation of Facility Modifications
(from Ref. V-2)

Isotope	Inventory of a Single Fuel Assembly at 450d Cooling (Ci) ^{b,e}	Estimated Total Facility Annual Release (Ci) ^{e,f,j}
Plutonium-Derived Isotopes: ^d		
Pu-238	1.07E+01	3.78E-10
Pu-239	4.02E+01	1.42E-09
Pu-240	4.13E+01	1.46E-09
Pu-241	1.37E+03	4.87E-08
Am-241	5.02E+00	1.78E-10
Am-242m	4.58E-02	1.62E-12
Am-242	4.22E-02	1.50E-12
Cm-242	5.89E+00	2.09E-10
Cm-244	1.90E-01	6.74E-12
Uranium Derived Isotopes: ^d		
U-234	1.19E-01	4.21E-12
U-235	3.63E-03	1.28E-13
U-236	6.40E-03	2.26E-13
U-237	3.37E-02	1.19E-12
U-238	4.44E-04	1.57E-14
Np-237	2.33E-03	8.23E-14
Np-239	2.14E-02	7.56E-13
Fission Products:		
Sr-89	7.10E+01	4.85E-09
Sr-90	9.63E+02	4.60E-08
Y-90	9.63E+02	4.58E-08
Y-91	1.89E+02	1.10E-08
Zr-95	3.98E+02	1.93E-08
Nb-95	8.74E+02	4.24E-08
Tc-99	1.85E-01	8.79E-12
Ru-103	1.25E+01	7.64E-10
Rh-103m	1.13E+01	6.88E-10
Ru-106	3.94E+03	1.85E-07
Rh-106	3.94E+03	1.88E-07
Sn-123 ^c	1.65E+01	7.86E-10

TABLE A-2 (cont.)

Isotope	Inventory of a Single Fuel Assembly at 450d Cooling (Ci) ^{b,e}	Estimated Total Facility Annual Release (Ci) ^{e,i,j}
Sb-125	3.04E+02	1.45E-08
Te-125m	7.42E+01	3.52E-09
Te-127m	2.84E+01	1.80E-09
Te-127	2.78E+01	1.73E-09
Te-129	7.75E-02	1.85E-10
Te-129m	1.19E-01	2.86E-10
I-129 ^h	5.43E-04	1.95E-14
I-131 ^h	3.84E-13	4.18E-11
Cs-134 ^h	1.01E+02	4.05E-09
Cs-136 ^h	1.41E-07	1.34E-10
Cs-137 ^h	1.36E+03	5.06E-08
Ba-137m	1.28E+03	4.78E-08
Ba-140	1.18E-06	3.49E-11
La-140	1.36E-06	4.03E-11
Ce-141	3.42E+00	1.18E-09
Pr-143	5.04E-06	5.08E-11
Ce-144	8.42E+03	4.02E-07
Pr-144	8.42E+03	4.01E-07
Pm-147	3.49E+03	1.67E-07
Sm-151	4.07E+01	1.94E-09
Eu-154	8.04E+00	3.88E-10
Eu-155	1.28E+02	6.38E-09
Fuel Cladding Activation Products: ^{f,g}		
V-49 ^C	1.15E-04	1.09E-15
Cr-51	2.50E-03	6.14E-14
Mn-54	2.34E+02	2.24E-09
Fe-55	2.10E+02	2.19E-09
Co-58	1.26E+00	1.21E-11
Fe-59	3.40E-02	3.44E-13
Ni-59	4.51E-04	4.26E-15
Co-60	7.53E-02	7.20E-13
Ni-63	1.16E-02	1.07E-13
Tc-99	3.98E-04	3.79E-15

TABLE A-2 (cont.)

-
- ^aColumn 3 is the (estimated) combined release of 100d cooled activity from process dust and of 450 d cooled activity due to resuspension of surface contamination. Column 2 is for 450 d cooled fuel only.
- ^bRead E+YY as $\times 10^{YY}$; also the use of 3 significant figures is not intended to imply predictions actually can be made at this accuracy level.
- ^cThese isotopes were not included in AIRDOS-RAD RISK calculations, but would make an insignificant contribution to the dose at estimated amounts of release.
- ^dPertinent isotopes only are listed, minor amounts of other isotopes will be present. U-236 release estimate corrected from that listed in Ref. V-2.
- ^eAn estimated 60 fuel assemblies will be processed per year of operation. For peak load estimate of 90 fuel assemblies per year, these values should be multiplied by a factor of 1.5.
- ^fAssumes HT-9 stainless steel clad material.
- ^gOnly 41.4% of the fuel cladding activity was assumed to be processed due to a head-end process which removes the fuel element plenums (i.e., the empty portion of the cladding above the fuel region which collects fission gases during irradiation).
- ^hExcept for small particulate and dust releases, these normally volatile elements are assumed to be confined to solid waste streams. Also, no Carbon-14 is shown here because of the projection that it also will be confined to solid waste streams and, because of lack of significant oxygen in the metal fuels, the generation rate is assumed to be low.
- ⁱBecause of problems with the AIRDOS-RAD RISK code accepting some isomeric states (e.g., Ru-103^m, Te-125^m, Te-127^m, Te-129^m, Ba-137^m and Am-242^m) it was necessary to combine some of the two-nuclide chains into a single dose conversion constant. This was done by simply adding the dose conversion constants and averaging the activities of the two nuclides.
- ^jRelative amounts of radionuclides may vary depending upon the specific fuel material processed, its power history and cooling time prior to processing, and actual vs. reported half-life of the nuclides. However, any such variations would have only a very minor effect on the total body dose because particulates contribute a very small fraction.

A.4 Ventilation and Stack assumptions

Stack Diameter - 1.55 m (5.1 ft)
Stack Height - 61 m (200 ft)
Flow Rate - 14.3 m³/s (30,200 cfm)
Heat Release Rate - negligible

A.5 Modeling Comparisons

Table A-3 gives a comparison of estimated radiological doses, calculated by original methods and by FPR protocol. Both methods used the AIRDOS-RADISK computer code. From the table it can be seen that, although the FPR-type modeling gives higher particulate doses, the total dose is reduced.

TABLE A-3

Estimated Effective Whole Body Committed Radiological
Doses for One Year Operation of HFEF/S, Evaluated at
Nearest INEL Site Boundary

	Dose (rem/y) ^{a,b} by Original Modeling	Dose (rem/y) ^{a,b} by FPR Protocol
Fission Product Particulates	2.12E-12	3.82E-12
Actinide Particulates	8.68E-12	1.37E-11
Fuel Cladding Activation Particulates	2.44E-15	2.47E-15
Noble Gas Fission Products	1.12E-07	1.12E-07
Tritium	2.64E-07	1.68E-07
Sodium Activation Particulates	3.24E-16	1.21E-15
TOTAL	3.76E-07	2.80E-07

^aThe use of three significant digits is not intended to imply that radiological dose can actually be predicted to this accuracy level.

^bBasis is processing of 60 fuel assemblies per year. For peak annual load of 90 fuel assemblies these numbers must be multiplied by a factor of 1.5.

APPENDIX B

ANALYSIS ASSUMPTIONS FOR ACCIDENT CALCULATIONS

B.1 Basic Mass and Isotopic Data - accident calculations (ORIGEN code derived)

1. Fuel assembly plutonium inventory after reactor irradiation for 1,076d at 0.7 MW power level (see Table B-1).

TABLE B-1

Pu Isotopic Mass in One U-Pu-Zr Discharged EBR-II
Fuel Assembly at 18% Heavy Metal Burnup, Cooled 110 Days^{a,c}

<u>Pu Isotope</u>	<u>Mass (g)</u>	<u>Weight Fraction</u>	<u>Curies</u>
238	0.995	0.00128	17.3
239	563	0.723	34.6
240	195	0.25	44.4
241	15.6	0.02	1753.4/49.9 ^b
242	<u>4.28</u>	<u>0.0055</u>	<u>0.0167</u>
Totals	778.9	1.0	1850/146.2

^aIn the EBR-II U-Pu-Zr fuel assembly, the radiological dose from the uranium isotopes is inconsequential compared to plutonium, therefore uranium was not included for preliminary accident calculations.

^bPu-241/Am-241.

^c4.42 kg heavy metal prior to irradiation. Post-irradiation masses are calculated with the ORIGEN computer code.

2. Fuel assembly fission product inventory after reactor irradiation for 1,076 days at 0.7 MW power level (see Table B-2).

TABLE B-2

Fission Product Inventory^b for One EBR-II
Fuel Assembly at 18% Heavy Metal Burnup,
Cooled 110 Days

Nuclide	Curies ^a	Nuclide	Curies ^a
Y90	1.72E+03	Rh106	8.46E+03
Y91	7.36E+03	Ag110m	4.04
La140	9.4E+01	Ag110	5.37E-02
Ce141	3.33E+03	Ag111	3.19E-02
Ce144	1.93E+04	Cd113m	1.37
Pr143	1.26E+02	Cd115m	4.58
Pr144	1.93E+04	Sn119m	3.9
Nd147	1.33E+01	Sn123	79.2
Pm148	5.63	Sn125	0.215
Pm148m	100.	Sb124	6.07
Sm151	7.22E+01	Sb125	5.6E+02
Eu154	2.7E+01	Sb126	0.431
Eu155	2.4E+02	Rb86	3.3
Eu156	3.35	Sr89	5.17E+03
Tb160	4.86	Sr90	1.72E+03
Zr93	4.25E-02	Te125m	1.31E+02
Zr95	1.11E+04	Te127	1.9E+02
Nb95	1.95E+04	Te127m	1.9E+02
Nb95m	82.2	Te129	59.7
Tc99	3.29E-01	Te129m	91.6
Ru103	3.6E+03	Cs134	4.3E+02
Ru106	8.46E+03	Cs137	2.5E+03
Rh103m	3.24E+03	Ba140	81.7

^a1.72E+YY means 1.72×10^{YY} .

^bCalculated with use of the ORIGEN computer code.

APPENDIX C

ACCIDENT CLASSIFICATION

The purpose of this appendix is to present the rationale for sorting potential HFEF/S accidents into likelihood of occurrence classifications that include anticipated, unlikely, extremely unlikely, and beyond design basis. Bounding accidents for each of these categories are described.

<u>ACCIDENT</u>	<u>PAGE</u>
<u>Anticipated Events ($>10^{-2}$ per year)</u>	
Release of All Argon Cell Atmosphere	C.2
Release of Fission Gas	C.4
<u>Unlikely Events (10^{-2} to 10^{-4} per year)</u>	
Waste Can Spill or Meltdown	C.5
Fuel Assembly Meltdown in Air Cell Storage Pit	C.7
Waste Box Burns in Basement	C.9
Metal Fire Due to Small Breach in Argon Cell	C.10
<u>Extremely Unlikely Events (10^{-4} to 10^{-6} year)</u>	
Metal Fire Due to Large Breach in Argon Cell	C.12
<u>Beyond Design Basis Events (10^{-6} to 10^{-8} per year)</u>	
Criticality	C.16
Metal Fire Due to Large [1.8 m (6 ft) dia] Breach in the Argon Cell - Unfiltered Release	C.17

Accident: Release of All Argon Cell Atmosphere

Classification: Anticipated

Summary of Rationale for Classification:

1. The bounding event for this type of accident, Release of All Argon Cell Atmosphere, was judged to be an anticipated event based upon engineering judgment. Although release of all cell atmosphere is improbable, several events of moderate likelihood can potentially lead to partial release of the argon cell atmosphere. These events include:
 - a. Failure of the redundant argon cell cooling system such that no cooling is provided. Considering the combination of cell heat sources (process heat, lighting, and decay heat) the cell atmosphere argon will heat up following loss of cooling causing cell pressurization and partial release of argon cell atmosphere through the argon cell exhaust system.
 - b. Fresh make-up argon is provided to the argon cell from argon cylinders by the means of argon lines, pressure controllers and valves. A combination of valve or controller failures could cause a continual flow of argon into the cell. To prevent overpressurization of the cell, the argon atmosphere would be bled off through the argon cell exhaust system.
 - c. The argon cell has several transfer ports to allow transfer of material into and out of the cell. These ports consist basically of an inner (argon cell side) and outer (air-side) hatch. An object to be transferred is placed between the hatches, and both hatches are closed. The volume between the two hatches is then pumped down and refilled with pure argon (to prevent air contamination of the argon in the argon cell

Accident: Release of All Argon Cell Atmosphere (cont.)

when the inner hatch is opened). If the inner hatch were to be left open, the inner hatch seal fail, or the control monitoring system fail, coupled with lack of attention by the operator, it is possible to exhaust the argon cell atmosphere with the vacuum pump. The pump exhaust is filtered through the air cell exhaust system.

- d. Inadvertent activation of the argon cell exhaust system as a result of pressure control or pressure switch failure could result in exhaust of argon cell atmosphere through the system filters.
2. Thus, the bounding event, Release of All Argon Cell Atmosphere, is a combination of several events. Engineering judgment dictates that while no single event has a high likelihood, the combined likelihood for the bounding event, Release of All Argon Cell Atmosphere, should be considered an anticipated event.

Accident: Release of Fission Gas

Classification: Anticipated

Summary of Rationale for Classification:

1. The bounding event for this type of accident, Release of Fission Gas, is based upon engineering judgment to be an anticipated event. Several events of moderate likelihood could lead to release of fission gas from a fission gas recovery system. Only conceptual design of the system is available. It consists of multiple components, valves, check valves, vacuum pumps, and fission gas storage cylinders. Any of these components could fail (by leaking, or gross failure) and result in release of fission gas. The most likely failure is a slow leak of fission gas.
2. Thus the bounding event, Release of Fission Gas, is a combination of many events. Engineering judgment dictates that while no single event has a high likelihood, the combined likelihood of all events incorporated into the the bounding event should be considered an anticipated event.

Accident: Waste Can Spill or Meltdown

Classification: Anticipated

Summary of Rationale for Classification:

The event, waste can spill or meltdown addresses the normal handling accidents associated with process wastes from the argon cell. Waste generated within the argon cell will be placed in small containers called inner waste containers, and sealed in the argon cell. The exact description of inner waste containers will be developed as the project matures. All inner waste containers are to be transferred into the air cell from the argon cell through the small transfer lock. The small transfer lock essentially consists of a small chamber that can be evacuated; with vacuum sealable doors to both the air cell and the argon cell. The event considers the combination of accidents occurring in the transfer lock and the air cell. In the air cell the sealed inner waste container is placed into an outer waste container using the air cell handling equipment. The outer waste container would have previously been placed inside the waste cask with the waste cask being located in the cask tunnel below the air cell. A shield plug and lid are placed on the outer waste container and the lid seal welded. Bagging techniques are used to provide containment and contamination control during the seal welding operation. The following items were considered in the classification of this event as an anticipated event.

1. The event is a bounding accident, considering the summation of many potential events in both the air cell and the small transfer lock.
2. Several filled inner waste containers per year will be transferred from the argon cell into and out of the air cell when in full operation.
3. Limited storage space exists for inner waste containers in the air cell.

Accident: Waste Can Spill or Meltdown (cont.)

4. All transfers are by means of E/M manipulators or air cell cranes and while the potential for a drop exists, it is of low likelihood. The drop may result in an inner waste container impact on either the floor or into the waste cask.
5. The inner waste containers are being designed to be passively cooled.
6. Air provides an improved passive cooling capability relative to argon, thus if a container is coolable in the argon cell it will be even more coolable in the air cell.
7. For a limited time (less than 30 minutes), during the transfer operation in the small transfer lock, the inner waste container is not passively cooled by natural convective cooling of air or argon but is in a vacuum. However, the combination of the decay heat being very low relative to the thermal mass of the inner waste container and the thermal radiation from the surface of the waste can to the transfer lock walls upon increasing temperature is such that the inner waste container temperature will not exceed acceptable temperatures for many hours or longer.
8. A large fraction of the inner waste containers will contain cladding hulls and fuel element plena with low contamination and decay heat.

As stated before, the exact description of the waste containers is under development. One option under consideration by the project is designing the inner waste containers to withstand the maximum credible drop, thereby reducing the likelihood of the accident.

Accident: Fuel Assembly Meltdown in Air Cell Storage Pit

Classification: Unlikely

Summary of Rationale for Classification:

1. Spent IFR fuel assemblies coming from EBR-II to HFEF/S enter the reprocessing (argon) cell via the air cell. In the air cell the fuel assemblies are disassembled to 61 individual fuel elements which are then moved into the argon cell for reprocessing. In the event of a processing backlog, or for other valid reasons, it may be necessary to store spent intact fuel assemblies for some time before they are reprocessed. The present plan is that such storage would be in above-floor racks in the air cell or in another facility. Existing air-cell floor pits will be used only for refabricated fuel assemblies, which generate negligible heat. (If it can be shown that spent fuel assemblies can be safely stored in the air-cell pits without relying on forced cooling, such fuel assemblies may be stored in the pits. This accident, however, assumes that passive cooling mechanisms are not adequate to assure the fuel assembly's integrity.) This accident, therefore, requires (a) that a spent fuel assembly be stored rather than dismantled after its entry into the air cell and (b) that the operator erroneously loads the fuel assembly into a storage pit.
2. Before a fuel assembly can enter the air cell, at least two people (usually three) must be cognizant of the move. Once in the air cell, the fuel assembly can be moved from one zone to another (e.g., from the transfer port to a storage pit) only with the concurrence of at least two people. The actual move is conducted by two fissile material handlers. Thus, erroneously loading a spent fuel assembly into a storage pit requires at least two human errors: either two errors authorizing the move and the two fissile material handlers not recognizing the error (total of four errors); or two errors by the fissile material handlers making an unauthorized move.

Accident: Fuel Assembly Meltdown in Air Cell Storage Pit (cont.)

3. Even if a spent fuel assembly is inadvertently loaded into a storage pit, it is not clear that overheating will occur. Studies are under way to determine whether the storage pits can be modified so as to assure passive cooling of one or more spent fuel assemblies. A preliminary assessment is that such a modification may be feasible.
4. Since this accident requires multiple human errors coupled with the presumed inability to passively cool a spent fuel assembly in a storage pit, it is assigned a classification of "unlikely". If present indications that a stored spent fuel assembly can be passively cooled are confirmed, this classification may be revised to at least "extremely unlikely".

Accident: Waste Box Burns in Basement

Classification: Unlikely

Summary of Rationale for Classification:

1. This accident assumes the uncontrolled combustion of a wooden radioactive-waste container inside the HFEF/S process building. The calculated accident consequences are based on a source term equivalent to twice the maximum permissible transuranic alpha contamination.
2. The wooden box is loaded in the bagout room with solid radioactive waste transferred through a bagout device located between the suited entry repair area and the bagout room. The bagout room will be ventilated by the air cell exhaust system and equipped with sprinklers.
3. The total heat produced by the alpha-generating waste is less than 10 milliwatts, which is more than three orders of magnitude greater than the total fission product decay energy contained in the waste. Hence, there is no concentrated source of energy sufficient to initiate a fire from within the box. In addition, minimal flammable solvents are used in the decontamination process that is a potential source of solid waste loaded into the wood container. Also, fire-retardant paint is used on the waste box.
4. A loaded waste box will not be stored in the bagout room but will be moved as soon as possible to the appropriate waste storage facility. Therefore, even if a waste box fire could start in the bagout room, it is very likely to be detected by personnel before the sprinkler is activated.
5. Because the above arguments indicate that a waste box fire is not expected to occur during the facility lifetime, this accident is classified as unlikely.

Accident: Metal Fire Due to Small Breach in Argon Cell

Classification: Unlikely

Summary of Rationale for Classification:

1. Occurrence of a metal fire in the argon cell requires that air (oxygen) be admitted to the cell in sufficient quantity to support combustion, and that hot metal be exposed to the oxygen-containing cell atmosphere.
2. Formation of a small breach (≤ 12.7 cm (5 in.) dia., 129 cm^2 (20 in.²)) in the cell boundary could occur by shear of a cell electrical or high purity argon penetration during movement of a heavy load within the cell or in the subcells. This event is considered of very low likelihood because: 1) of the limited time of exposure, 2) very few heavy loads are to be moved in the cell or subcells, 3) all penetrations are sealed at the bottom, and 4) such operations would be done under strict operational controls. Sliding motion of large unanchored equipment will be limited to assure no damage to penetrations during earthquakes.
3. Blowout of a penetration seal due to excessive differential pressure is similarly regarded as very improbable since the penetrations are sturdy, capable of significant differential loading without failure, and the capacity of the cell to sustain differential pressure is limited because of over pressure release through seal pots designed to assure no air reentry. (Seal pots are basically resealing pressure relief valves that have no mechanical moving parts.)
4. The project defense-in-depth policy is that all process equipment will be designed to provide confinement in an earthquake except for a limited quantity of metal necessary for transfer or chopping operations.
5. Seismic evaluation of the cell for the design basis earthquake results in the following conclusions/actions:

Accident: Metal Fire Due to Small Breach in Argon Cell (cont.)

- a) The cell steel liner will remain intact.
 - b) All penetrations, failures of which could result in a direct release of radioactivity to the building or environment, are being evaluated to determine their response in an earthquake. The penetrations will be evaluated to ensure that failure will not cause a breach of sufficient area to defeat the proper operation of the argon cell exhaust system, and if necessary the penetrations will be modified to assure no significant failure.
 - c) Seismic restraint will be added to prevent significant motion of the cell windows.
6. Fire and/or explosions are also potential causes of a small breach in the argon cell and were considered in this event classification. Very significant measures are being undertaken by the project to prevent fires or explosions causing large breaches in the cell (see event - Metal Fire Due to Large Breach in Argon Cell; Rationale 7 and 8). These measures also, in general, preclude small breaches except that small fires could result in penetration seal failures as a result of local overheating.
7. Although the above arguments would ordinarily make this accident an "extremely unlikely" event, the likelihood of the event has been elevated to unlikely because of the numerous small penetrations in the cell boundary.

Accident: Metal Fire Due to Large Breach in Argon Cell

Classification: Extremely Unlikely

Summary of Rationale for Accident Classification:

1. Occurrence of a metal fire in the cell requires that air (oxygen) be admitted to the cell in sufficient quantity to support combustion, and that hot metal be exposed to the oxygen-containing cell atmosphere.
2. Formation of a large breach ($\leq 930 \text{ cm}^2$ (1 ft²), 34 cm (1.1 ft) dia.) could occur by shearing of multiple cell penetrations during movement of a heavy load within the cell or in the subcells. This event is considered of extremely low likelihood because: 1) of the limited time of exposure, 2) very few heavy loads are to be moved in the cell or subcells, 3) all penetrations are sealed at the bottom in the subcells, and 4) such operations would be done under strict operational controls. Sliding motion of large unanchored equipment will be limited to assure no damage to penetrations during earthquakes.
3. Blowout of multiple penetration seals due to excessive differential pressure is similarly regarded as extremely improbable since the penetrations are sturdy, capable of withstanding significant differential pressure without failure, and the cell differential pressure is limited to inches of water because of over pressure release through seal pots that are also designed to assure no air reentry. (Seal pots are basically resealing pressure relief valves that have no mechanical moving parts.)
4. The project defense-in-depth policy is that all process equipment will be designed to provide confinement in an earthquake except for a limited quantity of metal necessary for transfer or chopping operations.

Accident: Metal Fire Due to Large Breach in Argon Cell (cont.)

5. Seismic evaluation of the cell for the design basis earthquake results in the following conclusions/actions:
 - a) The cell steel liner will remain intact.
 - b) All penetrations, failures of which could result in a direct release of radioactivity to the building or environment, are being evaluated to determine their response in an earthquake. The penetrations will be evaluated to ensure that failure will not cause a breach of sufficient area to defeat the proper operation of the argon cell exhaust system, and if necessary the penetrations will be modified to assure no significant failure.
 - c) Seismic restraint will be added to the cell windows to prevent significant motion.
6. The large transfer lock transfer mechanism is being designed to withstand a drop impact load of 1000 lbs. No load transfers in excess of 1000 lb will be allowed in the argon cell with pyrophoric material exposed to the cell atmosphere.
7. A fire of sufficient magnitude to cause a large breach of the argon cell is extremely unlikely for the following reasons:
 - a. The fuel cycle facility building is primarily constructed of fire-resistant and non-combustible materials; it will be almost entirely sprinklered outside the transfer, air, and argon cells.
 - b. The use and/or storage of ordinary combustibles and flammable solvents in the facility will be kept to a practical minimum. (Solvents are not needed to support the process in the argon cell because only metals and salts are used.)

Accident: Metal Fire Due to Large Breach in Argon Cell (cont.)

- c. The on-site fire department operated by DOE provides around-the-clock coverage of the ANL-W site, with a maximum response time of less than five minutes. If necessary, additional backup from INEL Central Facilities can be available within 40 minutes.
 - d. Fire-water pumping capacity will be upgraded to meet the estimated peak demand.
 - e. A fire barrier with a minimum 1-hr rating will separate the argon cell and air cell corridors on the operating floor.
 - f. Gasoline-powered vehicles will not be permitted within the building.
 - g. Modifications necessary to upgrade the facility to an improved risk level of fire protection as defined in DOE order 5480.7 will be accomplished.
8. Similar considerations apply to the prevention of explosions. The major source of explosive materials, excluding those identified above as potential fire sources, is hydrogen that is either used in the argon cell atmosphere purification system or that results from battery-charging. In the former case, the hydrogen storage cylinder will be outside the facility with piping into the building to the argon cell atmosphere purification system.* Controls and protective devices will be employed to prevent accumulation of hydrogen in the building. Battery-charging will only be allowed in areas where there is adequate ventilation to prevent the hydrogen concentration from reaching the lower explosive limit.

*A design alternative under consideration is location within the building of a small hydrogen cylinder, but limiting the volume to an amount small enough that no explosion hazard exists. The large hydrogen supply would be maintained outside the building with no piping into the building.

Accident: Metal Fire Due to Large Breach in Argon Cell (cont.)

9. Based upon evaluation of the multiple independent events and the levels of protection provided this bounding event by the design and operation, a classification of "extremely unlikely" is assigned.

Accident: Criticality

Classification: Beyond design basis (preliminary classification)

Summary of Rationale for Classification:

1. The HFEF/S Modifications Project is attempting to design provisions for criticality safety to go beyond current DOE and industry standards (cf. DOE Order 6430.1A and ANSI/ANS-8.1-1983). In particular, whereas the noted standards would not necessarily proscribe operations in which a criticality accident could happen if only two "unlikely" events occurred, HFEF/S is designing so that no credible combination of abnormal conditions could lead to criticality.

Specifically, the project criticality-safety goal* is

"Nuclear criticality safety, which is generally achieved through a composite of design and administrative measures, shall ensure that operations involving fissile material are conducted such that a safe margin of subcriticality exists during all normal and credible abnormal conditions. Primary reliance shall be placed on equipment design rather than on administrative controls."

2. In order to meet the goal, considerable effort has been spent and is continuing during the preliminary and final process equipment designs to provide equipment design features and strict administrative operating controls that together will assure compliance with the essence of the basic goal, i.e., that accidental criticality shall be rendered sufficiently unlikely as to be classified beyond the design basis.

*In preliminary safety analyses the "goal" was treated as a "criterion" with recognition that, where human interaction is required it might not be completely possible to achieve the criterion. In this case the event would be reclassified as "extremely unlikely".

Accident: Metal Fire Due to Large (1.8 m (6 ft) dia) Breach in the Argon Cell
- Unfiltered Release

Classification: Beyond Design Basis

Summary of Rationale for Classification:

This event is very similar to the design basis event, Metal Fire Due to Large Breach in the Argon Cell, except for two assumptions:

1. A larger (1.8 m (6 ft) dia) breach occurs in the argon cell, and
2. The argon cell exhaust system fails.

The design basis event, Metal Fire Due to Large Breach in the Argon Cell, was classed as "Extremely Unlikely". Because of the low likelihood of a large breach and failure of the safety class argon cell exhaust system, this event, Metal Fire Due to Large (1.8 m (6 ft) dia) Breach in the Argon Cell - Unfiltered Release, has been classified as Beyond Design Basis. Because all the elevated-temperature pyrophoric process material is assumed to be involved in the fire and the release is unfiltered, this may be considered the bounding event for beyond-design-basis accidents.

APPENDIX D

LIST OF ABBREVIATIONS

α	Alpha - a helium nucleus - a type of ionizing radiation
β	Beta - an electron - a type of ionizing radiation
γ	gamma - a photon - a type of ionizing radiation
$\mu\text{g/y}$	micrograms per year
AIRDOS-EPA	Computer Code for Calculating Concentrations of Radionuclides Released Off-site
BeO	Beryllium Oxide
$^{\circ}\text{C}$	Celsius Temperature
C-14	A radioactive isotope of Carbon
Cd	Cadmium
cfm	cubic feet per minute
Ci	Curie - A unit describing the quantity of radioactive material
Ci/y	Curies per year
Cl_3	Chlorine in form of a chloride compound
cm	centimeter
CO	Carbon Monoxide
Cs	Cesium
CsI	Cesium Iodide
d	day
DBA	Design Basis Accident
dBA	unit of noise level
D-G	diesel/generator
dia	diameter
DOP	Diethylphthalate - An approved particulate aerosol for testing filter efficiency
$^{\circ}\text{F}$	Fahrenheit temperature
ft	feet
FPR	Fuel Processing Restoration
FY	Fiscal Year
g	Gravitational Acceleration at Surface of Earth
gal	Gallon
H-3	Tritium - a radioactive isotope of hydrogen
I-131	A radioactive isotope of iodine
in.	inch
kg	kilogram
kg/y	kilograms per year
km	kilometer
km/h	kilometer per hour
Kr-85	Radioactive Isotope of Krypton
kw-h	kilowatt-hours
L	liter
lb	pound
lb/y	pounds per year
m	meter
m^3	cubic meter
m^3/s	Cubic meters per second
man-Rem/y	A unit describing the total radiation received by a population in one year
mg/m^3	milligrams per cubic meter

LIST OF ABBREVIATIONS (cont'd)

mi/h	Miles per hour
mi	mile
min	minute
mRem	milliRem - a small unit of radiation exposure
mR/hr	milliRem per hour
m/s	meter per second
mt/y	metric tons per year
mW	milliwatt
MW-hr	Megawatt hours
Na	Sodium
NaI	Sodium Iodide
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO _x	Oxides of nitrogen
NRC	Nuclear Regulatory Commission
ORIGEN	A computer code to compute radioactive decay
PSD	Prevention of Significant Deterioration
Pu	Plutonium
rad	A unit of radiation exposure
RADRISK	Computer Code Used to Calculate Radiological Dose
Ref.	Reference
Rem	A unit of absorbed radiation that includes a factor that scales the relative biological damage for different types of radiation
Rem/y	Rem per year
s	second
SO ₂	Sulphur Dioxide
SO _x	Oxides of sulphur
Sr	Strontium
TRU	Transuranic
t/y	tons per year
U	Uranium
U-Pu	Uranium-Plutonium Alloy
U-Pu-Zr	Uranium-Plutonium-Zirconium Alloy
U-Zr	Uranium-Zirconium Alloy
Xe-131m	A metastable isotope of Xenon
Xe-133	Radioactive Isotope of Xenon
y	year
ZrC	Zirconium Carbide

APPENDIX E

Photographs of the Site and Facility for the Proposed Action

E.1

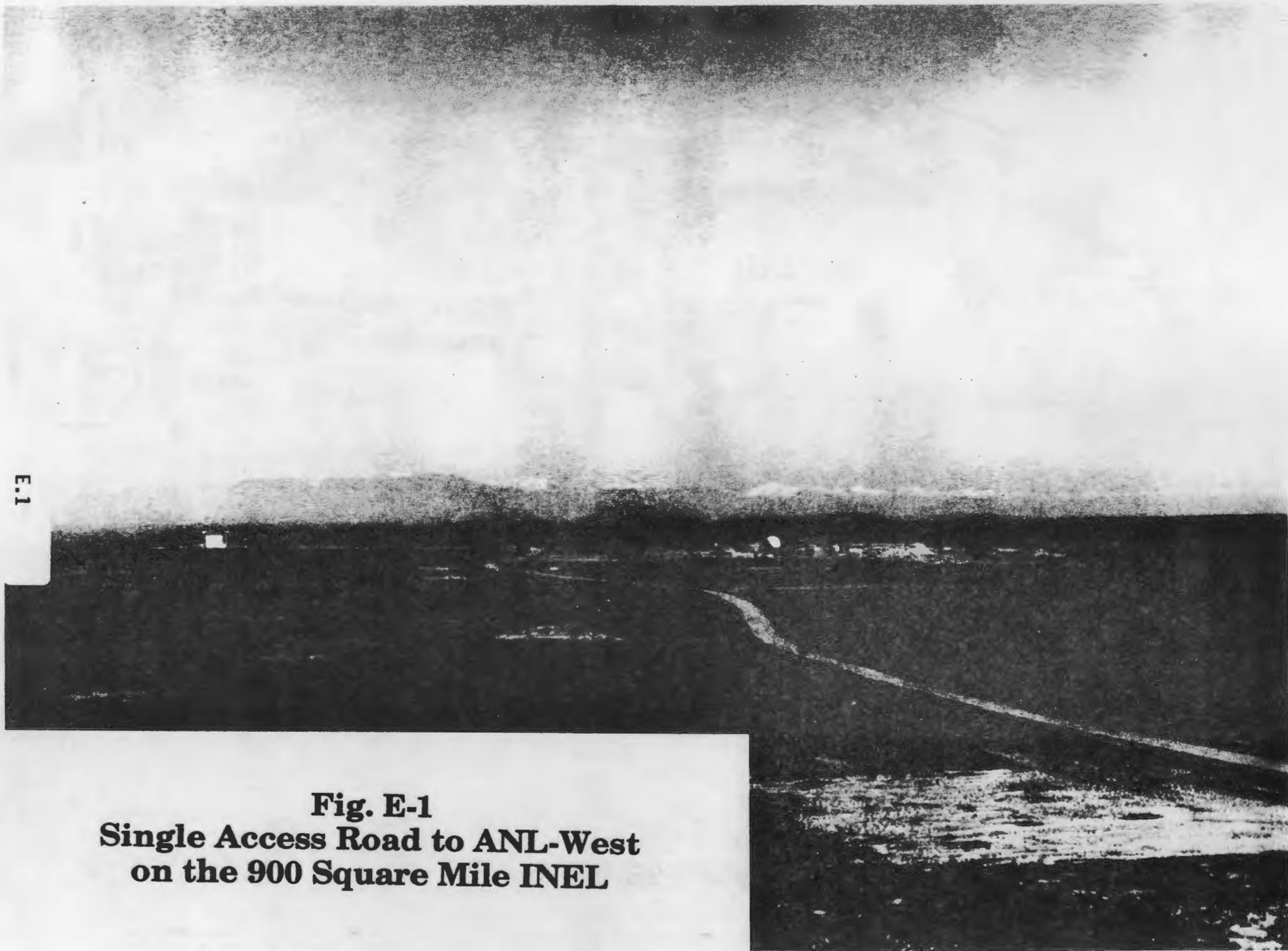


Fig. E-1
Single Access Road to ANL-West
on the 900 Square Mile INEL

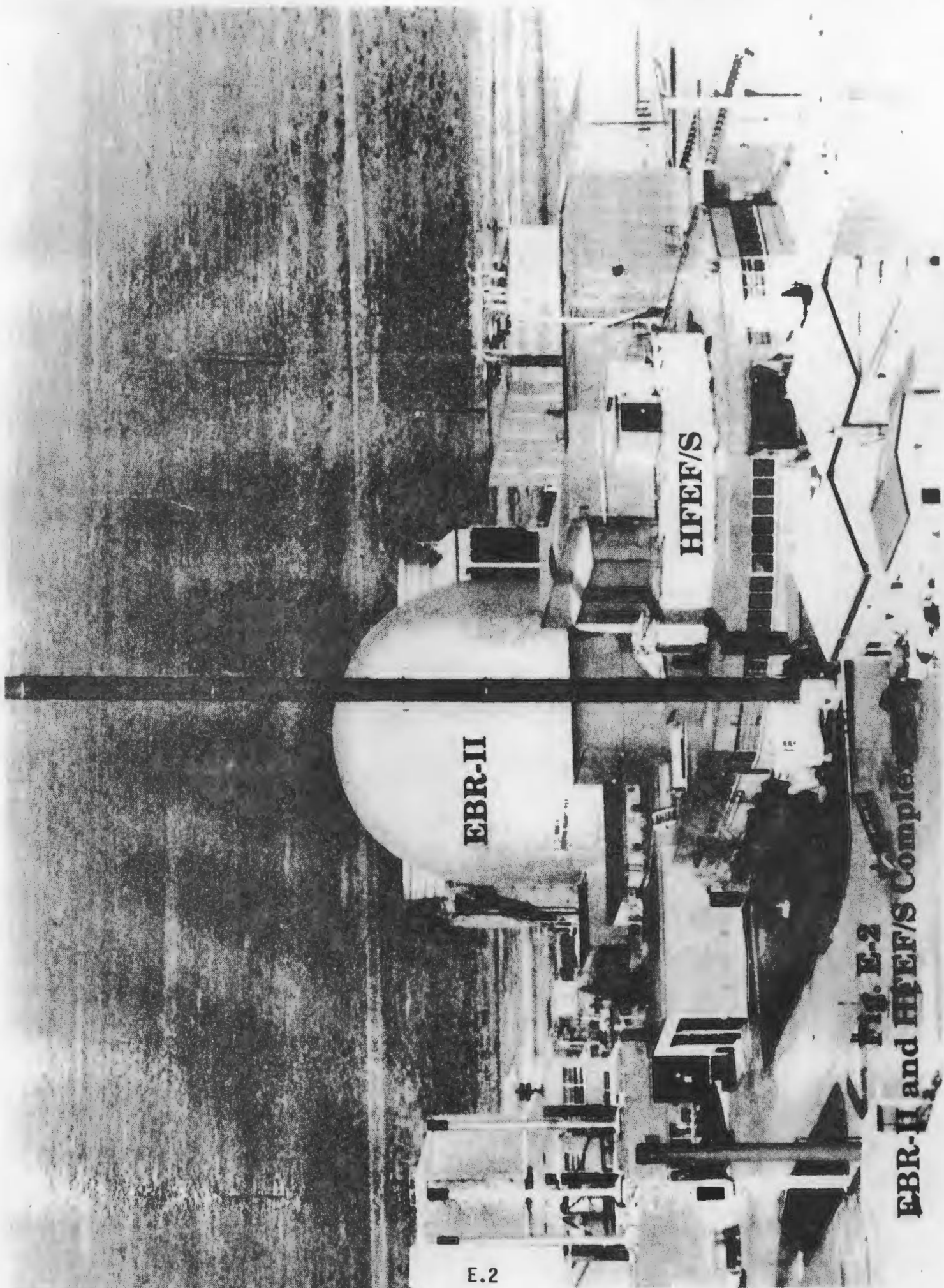


Fig. E-2
EBR-II and HFEEF/S Complex

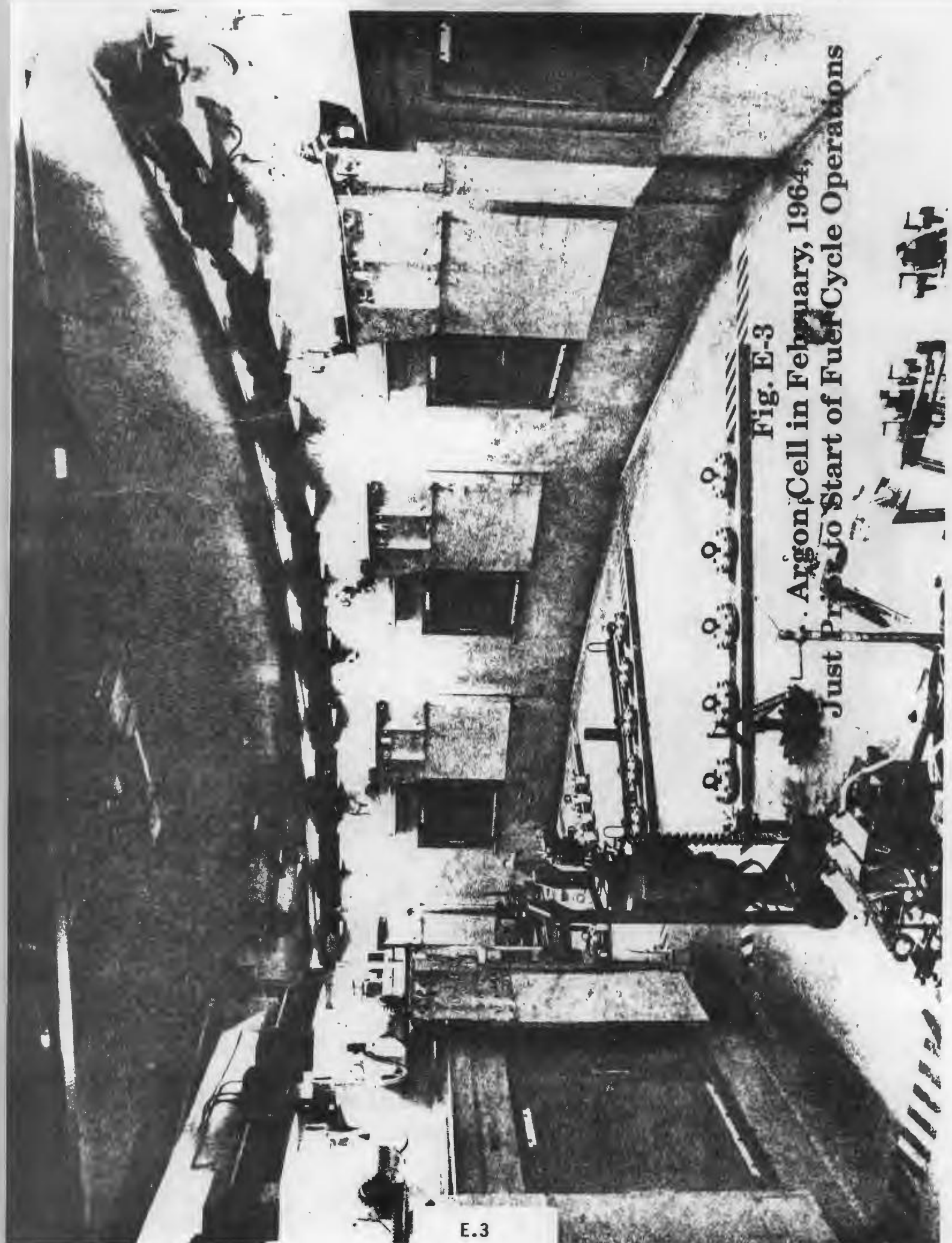
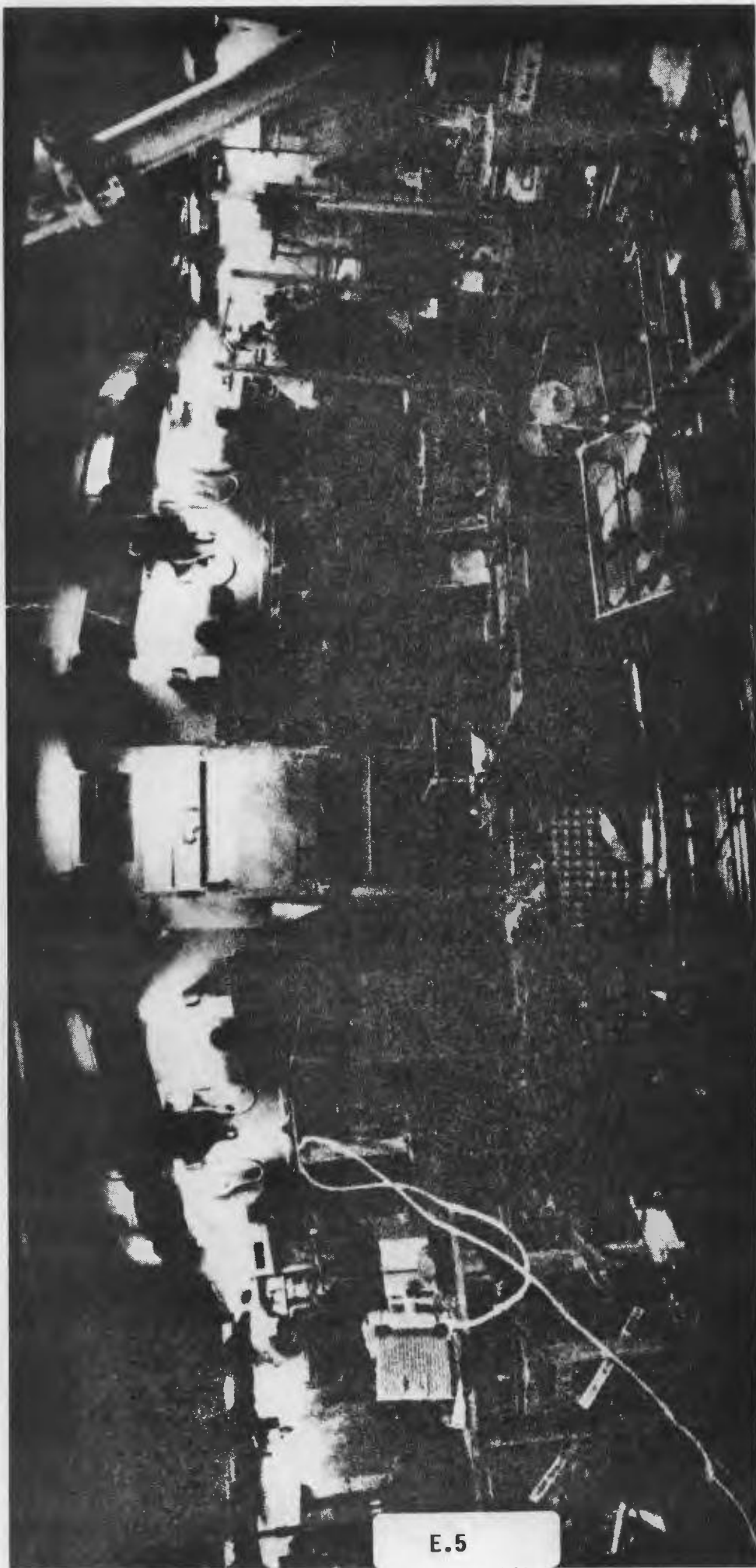


Fig. E-3

Argon Cell in February, 1964,
Just Prior to Start of Fuel Cycle Operations



Fig. E-4
Photo Mosaic of Equipment in Argon Cell
Prior to FCF Operation (3/25/64)



E.5

Fig. E-5
Equipment in Argon Cell Following Completion
of Fuel Cycle Demonstration (1970)

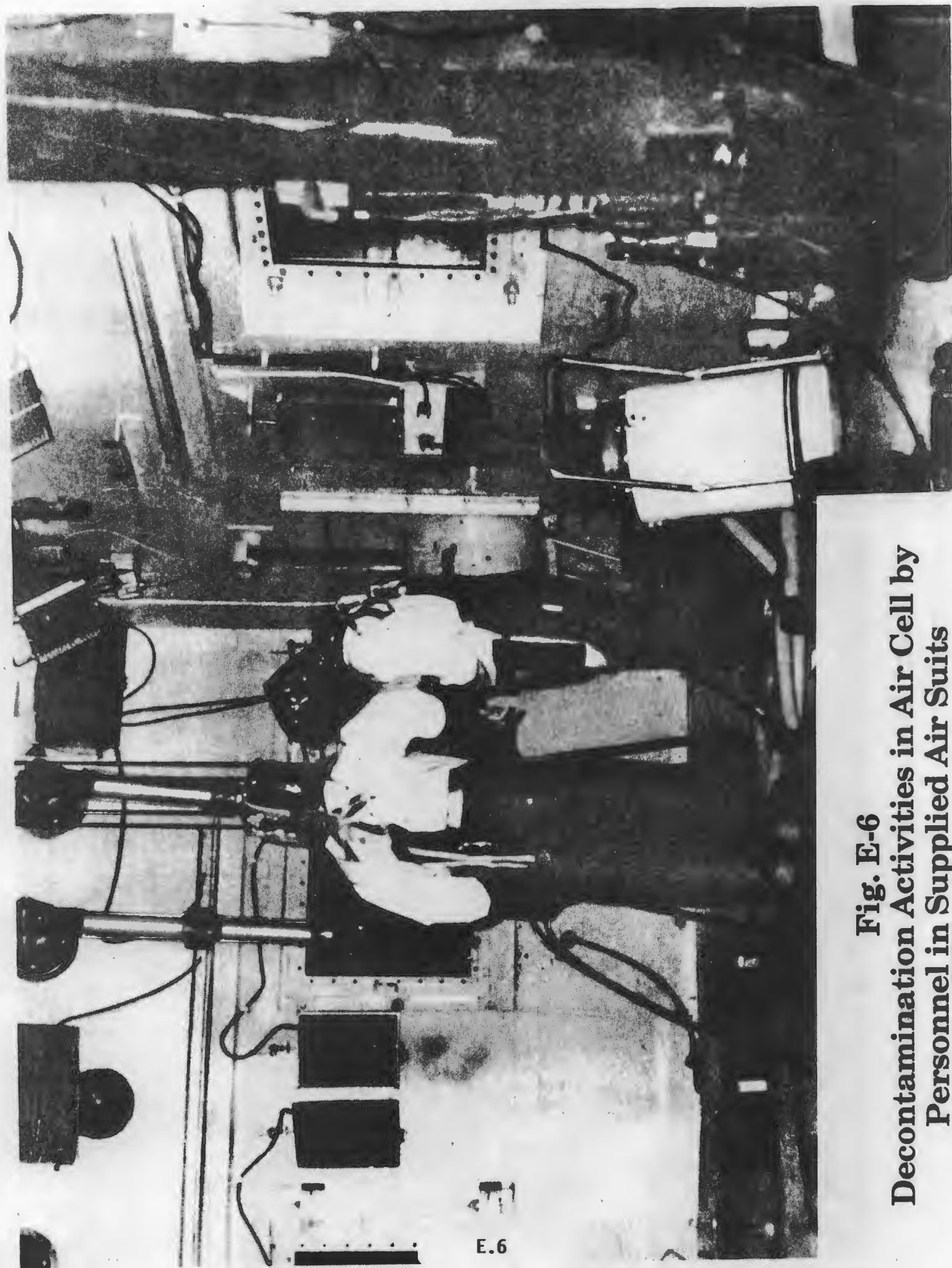


Fig. E-6
Decontamination Activities in Air Cell by
Personnel in Supplied Air Suits

APPENDIX F

ANL-W GEOLOGICAL OVERVIEW

The ANL-W facility is located within the Idaho National Engineering Laboratory near the center of the eastern Snake River Plain. The eastern plain is underlain by quaternary volcanic rocks (primarily basalt) with interbedded sedimentary deposits (Bigelow, et al., 1986). At the ANL-W facility the basaltic lava flows and associated pyroclastic deposits are relatively older flows (Pleistocene age) of the Snake River Group and may be as much as 5,000 feet thick (LaPoint, 1977; Lindholm, 1988). The sequence of basaltic rocks and intercalated sediments comprise the Snake River Plain Aquifer. The depth to the water table is approximately 630 feet below the ground surface within the area of ANL facility.

F.1 Surface Geology*

The Argonne-West Site occupies a rectangular area of approximately 810 acres with the INEL included in sections 11, 12, 13 and 14 of T3N R32E as depicted on the USGS survey map presented in Fig. F-1. The topographic relief within the site is about 50 feet. Altitudes range from 5,110 feet above mean sea level on the north boundary to about 5,160 feet on a basalt ridge near the southeast corner of the site. The Argonne-West facilities are constructed on the alluvial plain of a closed basin. The alluvial plain gradually slopes from the south to the north at a rate of approximately 30 feet per mile.

Low ridges of basalt located east of the area rise as high as 100 feet above the level of the plain. Surfaces of exposed basalt flows are gently rolling. Much of the general area is covered with basalt outcroppings while the remainder consists of silt and sand deposits covering intermittent layers of basalt flows and sediment. Wind blow deposits of varied thickness cover the entire area.

Olivine basalt is the dominant rock type. Coatings and cavity fillings of calcareous material are common in the basalt. Color differences are common in flow layers. The dominant colors are shades of gray; however,

* Ref: ANL-W, 1989

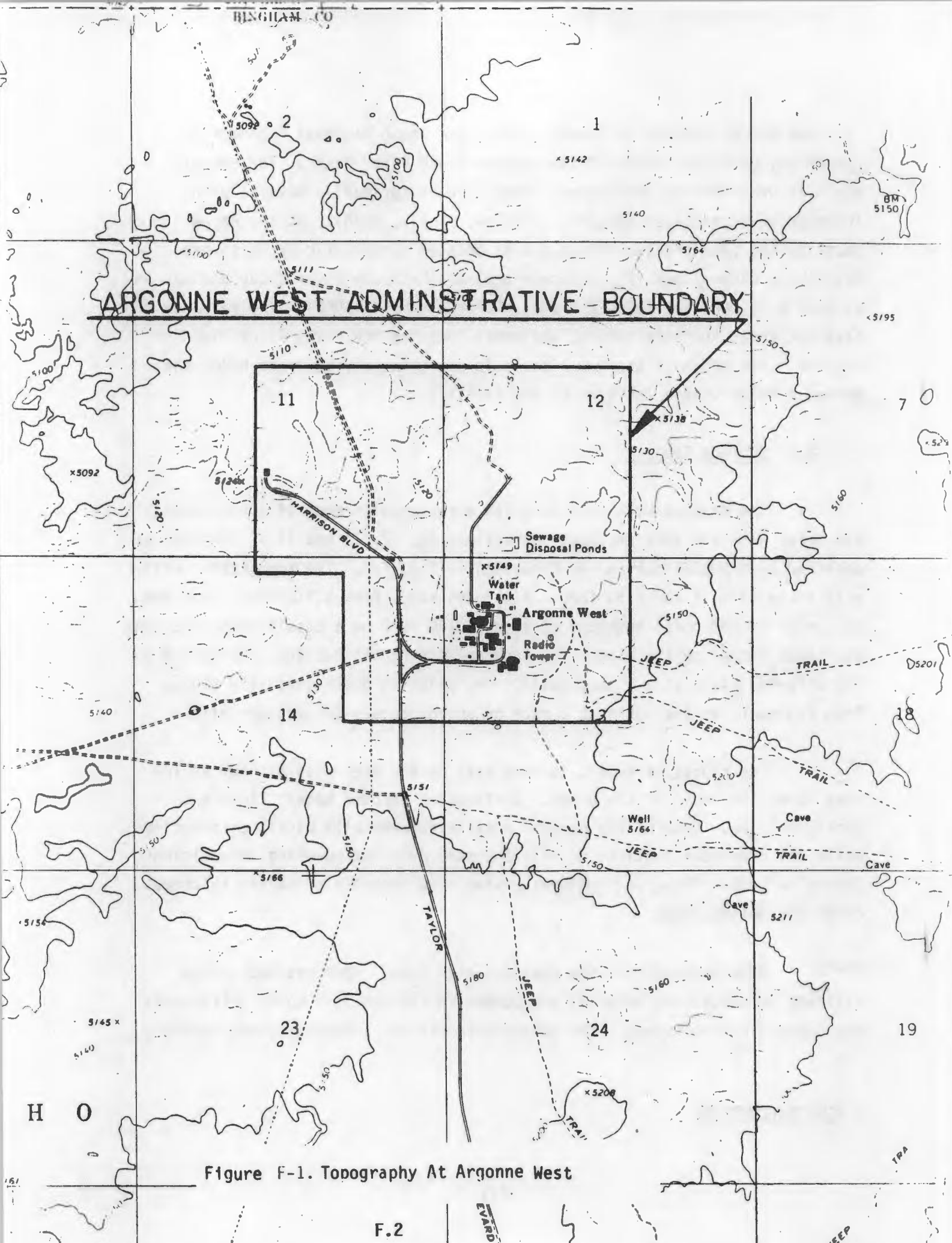


Figure F-1. Topography At Argonne West

shades of red, purple, and black exist. The texture of the basalt is glassy to medium grained. The internal structure ranges from dense to scoriaceous and cindery. Most of the basalt is minutely to coarsely vesicular. Jointing, fracturing, and layering are common in the basalt. A few basalt layers have been broken locally into loose blocks by mechanical weathering (frost-pry). These effects are minor except in the upper 1 or 2 feet of exposed layers.

As indicated from soil core samples and visual observations, a mantle of windblown fine sand and soil (loess) covers most of the area. These materials are believed to have originated by deposition of material transported by wind from other parts of the plain. This material exhibits a thickness of zero on the outcrops to 10 to 15 feet at some of the lower levels. The loess is of light buff to brown, calcareous, and of sandy-silt texture. Small bodies of well-sorted sand occur with the loess.

Test borings at the Argonne-West Site reveal that the site in general is blanketed by zero to several feet of light brown silty loam. The upper one to two feet of this silty loam contain roots. The light brown silty loam is underlain by light brown silt which extends to the underlying lava rock. In general, the lower portion of the silt contains lava fragments of cobble to boulder size. The thickness of the zone containing the lava fragments ranges from approximately one to nine feet. The upper surface of the lava rock is highly irregular.

The silty loam and silt are relatively loose windblown deposits which are moderately firm and compressible at their present in-place moisture content and density. However, these soils are subject to an appreciable decrease in strength and increase in compressibility with an increase in moisture content.

The lava underlying the site is probably of the Pahoehoe flow type. This lava crops out at several locations in the general vicinity of the site and the outcrops are fractured horizontally and vertically. Approximately one mile southeast of the site the lava is cavernous and lava flow by the hardening of the surface of the molten stream and the stiffening

of its side walls, while the liquid interior drains away, leaving an empty tunnel. After the tube is formed, there are portions of its roof which are unstable and the collapse of a portion of the roof forms an entrance to the tube, making a cave.

Studies conducted throughout the INEL have been useful in determining the mineral composition of the silt and clay fractions of the Big Lost River alluvium and sedimentary interbeds. Common clay mineral percentage composition values are montmorillonite - 36%, illite - 27%, and dolomite - 11%. The remaining material balance is associated with silt including quartz - 12%, calcite - 13%, feldspar - 5%, and traces of dolomite. The values represent averages of many samples and do not total 100% (Nace, et al., 1956).

F.2 Sub-Surface Geology*

Two categories of data are available which may be used to develop a general understanding of strata located beneath the Argonne-West Site. In a general sense, the subsurface beneath the site consists of alternating layers of basalt and sediment which differ widely in volume and distribution. Well log data for Argonne-West are helpful in describing the contours of stratum which may be present beneath the Argonne-West Site. The location of these wells and bore holes are shown on Fig. F-2. On the basis of information that is now available few of the individual stratum can be correlated between holes that are more than a few feet apart. However, the well log data does represent a starting point for analyzing subsurface conditions. Well log data may also be supplemented with borehole information from a variety of investigations conducted throughout the operational history of Argonne-West. Together the two classes of information are useful in describing local geology pertaining to the installation of a monitoring system.

Shallow test holes in the area show that surfaces of buried basalt have rolling configurations and relief similar to exposed basalt. Well logs

* Ref: ANL-W, 1989

and shallow boreholes indicate that the first layer of basalt beneath the area is encountered at depths from the ground surface to approximately 20 feet. There are numerous fractures and joints in the upper few feet of the buried basalt which have been filled with silt or granular to powdery calcite. Sedimentary interflow beds of calcareous silt, sand, and gravel ranging in thickness from less than one inch to almost ten feet also occur at various depths and rest upon the upper surface of the basalt layer. These interbeds are old soils and fragmental sediments similar to those present at the current land surface. In contact with these sediments, the surface of this basalt layer is impermeable to some degree and may act to impede flow resulting in the formation of zones of perched water.

In particular, the EBR-II production wells, the Site 16 observation well, and data available on these wells, drillers and geophysical logs, will approximate the nearby hydrogeologic characterization. Other wells in the vicinity help delineate any hydrogeologic trends that may exist, such as prominent interbedded sedimentary units. These wells are USGS observation wells Arbor Test and number 100, and a backfilled borehole about 250-feet deep, designated DH-50, a borehole 90-feet deep, designated DH-8. Due to their proximity, the lithologic sequence penetrated by these wells and bore holes should approximate that under the subject ditch. A number of bore holes were drilled and logged adjacent to the Industrial Waste Pond in 1987 (See Appendix H). Data from those holes also substantiate the major hydrogeologic trends.

The surficial alluvium at the Blowdown Ditch is a few to about ten feet thick. Clay to silt sized material near the base of the deposit, immediately above the underlying basalt flow, could perch downward percolating water if a recharge source is available, such as the industrial waste water. Following a series of basalt flows, another fine-grained sedimentary unit occurs at a depth of about 50 feet. This areally non-extensive deposit may be as much as ten feet thick or non-existent where it correlates to the top of a basalt flow. Neutron logs of surrounding wells suggest that this unit may perch or be saturated with water. In fact, well 100 neutron logs suggest partially saturated conditions at this depth and the sedimentary unit is

absent. Sedimentary infilling of fractures and voids at the top of a basalt flow has probably created this potential perching condition (Lewis 1987).

However, the six bore holes drilled through this layer at the adjacent Industrial Waste Pond in 1987 (see Appendix H) did not find a perched water table. Some pockets of water were found trapped in cracks and crevices and some dampness in some of the soil interbeds but no perched water. After the crack or crevice labyrinth was penetrated, water would drain for a period of time and then essentially dry up. Bore hole M4 illustrates this condition and was one of five holes drilled to approximately 60 feet. Bore hole M6 was drilled to 420 feet. The interbeds encountered thus appear to be sufficiently pervious in combination with possible discontinuities so as to not perch water with the percolation rates available. The major lava flows and interbeds appear to correlate quite well with the other wells and bore holes at the Argonne site.

Basalt flows dominate the lithologic sequence from a depth of about 50 to 260 feet. Two cinder zones exist in the interval from about 260 to 300 feet. Each cinder zone may be as much as 120-feet thick and they are separated by a basalt flow about ten feet thick.

Another fine-grained interbedded sedimentary units exists below another series of basalt flows at a depth of about 400 feet. Neutron logs of nearby wells also indicate that this ten foot thick areally extensive unit may perch or be saturated with water. The 420 foot hole drilled in 1987 found saturated soil but not a perched water table. Another sedimentary zone, somewhat coarser grained, occurs at a depth of about 550 feet. Neutron logs also indicate that this ten foot thick areally extensive unit may perch or retain percolating water.

Underlying a series of thin basalt flow, a very fine-grained sedimentary unit (clay) occurs at a depth of about 600 feet. Neutron logs also show that this areally extensive, eight foot thick deposit may perch or be saturated with water. A neutron log of well 100 indicates that the entire basalt sequence, about 40-feet thick and between the 500- and 600-foot

sedimentary interbeds, may be saturated or partially saturated with perched water. Gamma logs show that the basalt flows underlying the 600-foot interbed have a high degree of sedimentary infilling and indicates that even in the absence of the sedimentary interbed, this horizon could still perch water. This "dirty" basalt sequence is about 40-feet thick and the regional water table is at a depth of about 630 feet, near the flow's base. The remainder of the lithologic sequence below the water table appears to be composed primarily of competent basalt flows, at least to a depth of about 760 feet (Lewis 1987).

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2. Bigelow, B. B., S. A. Godell, and G. D. Newton, 1986, "Water Withdrawn for Irrigation in 1980 on the Snake River Plain, Idaho and Eastern Oregon," U.S. Geological Survey Hydrologic Investigations Atlas HA-690, 2 sheets.
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4. Lindholm, G. F. 1988, "Hydrogeologic Overview of the Eastern Snake River Plain, Idaho", Geological Society of America, Rocky Mountain Section, p. 428.
5. Lewis, B. D., 1987, written communication to E. W. Krenz, "Hydrogeologic Sequence at EBR-II".
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APPENDIX G

GROUND AND SURFACE WATER

G.1 GROUNDWATER*

G.1.1 Snake River Plain Aquifer, General

The entire eastern portion of the Snake River Plain (10,800 square miles) is underlain by a vast groundwater reservoir known as the Snake River Plain aquifer. The aquifer may contain more than 500 million acre-feet of water. Stratigraphically, the aquifer consists of a series of basalt lava flows, with volcanic ash and highly fractured rock zones along the flow contacts and sedimentary deposits of sand, gravels, and clays between the lava flows. The total thickness of the aquifer is not known. Evidence indicates that the aquifer may be between one and ten thousand feet thick (Robertson, et al., 1974). Recent data collected from INEL well 1 suggests that the base of the aquifer is between 850 to 1,220 feet below the land surface. (Mann, 1986).

Underlying the Snake River Plain aquifer is another water bearing zone approximately 8,500 feet thick and of lower permeability (Mann 1986). Separating this zone from the main aquifer is a poorly permeable sedimentary interbed from 1,220 to 1,540 and the altered and mineralized basalts from 1,540 to 2,170 feet. Some limited mixing of this water may occur with the Snake River Plain aquifer. Carbon dating of groundwater extracted from the lower zone at 3,500 feet indicates that water in this region is approximately 35,000 years old as compared to the relatively younger main aquifer (Barracough, 1985).

Much of the Snake River Plain aquifer is discharged to the Snake River through the Thousand Springs at Hagerman. The hydraulic head ranges from zero at the discharge of some of the springs to perhaps tens of feet above the land surface at some of the areas approaching the springs. The hydraulic gradient then slopes up to about 1,000 feet below the land surface in the area a few miles southwest of the INEL.

* (Ref: ANL-W, 1989)

Overall, the groundwater follows the gently sloping regional topography of the Eastern Snake River Plain from northeast to southwest. Fig. G-1 depicts the water table elevation and a north-south cross section of the aquifer. In Jefferson County, near Market Lake, and extending across the aquifer is a region called the Market Lake barrier which impedes groundwater flow. Beyond the Market Lake barrier the water table is relatively flat as the groundwater moves southwest into Bingham County and the American Falls area. Here, large springs discharge into the Snake River. West of the American Falls area, near Blaine County, another barrier at the Great Rift Zone causes the water table gradient to become steeper. West of the Great Rift Zone, the groundwater proceeds towards the Snake River Canyon where it issues from numerous springs in the canyon wall. Groundwater generally flows southwest through the aquifer from the north and northeast recharge areas to the south and southwest discharge areas. The average water table gradient across the entire Snake River Plain aquifer is approximately ten feet per mile (Robertson, et al., 1974), and 5 feet per mile to the southwest across the INEL.

The Yearly recharge to and discharge from the aquifer is approximately eight million acre-feet. Table G-1 identifies primary sources of recharge and discharge (Hackett, et al., 1986).

Data presented in Table G-1 indicates that the greatest recharge to the aquifer results from the deep percolation of irrigation water onto the plain as well as valley underflow from 35,000 square miles of recharge area in the mountains north and northeast of the plain. The greatest discharge from the aquifer occurs through springs and river gains, although pumping to meet irrigation demands also draws large volumes of water from the aquifer. The contributions from the INEL percolation ponds are so small in comparison that they are not listed (see appendix H).

The transmissivity of the aquifer generally ranges from 130,000 to 13 million feet squared per day. The average transmissivity is approximately 670,000 feet squared per day (Norvitch, 1969). Storage coefficients of the aquifer are highly variable with location and time, ranging from 0.001 to

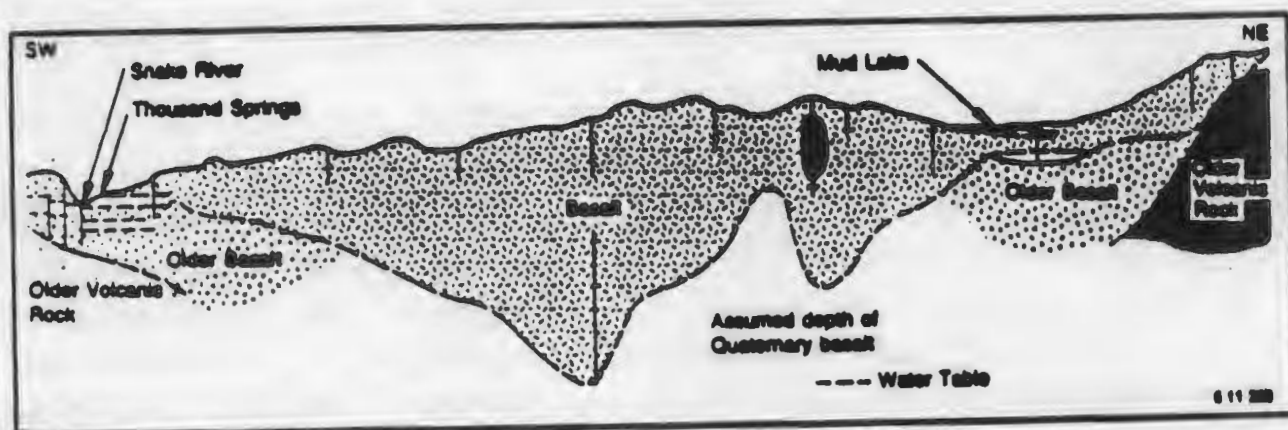


Fig. G-1. Eastern Snake River Plain Aquifer and Geologic Cross Section (Lindholm et al., 1983)

TABLE G-1
Inflow to and Outflow From the Snake River Plain Aquifer
(Hackett, et al., 1986)

Source	Recharge (millions of acre-feet)	Discharge (millions of acre-feet)
Irrigation Diversions	5.1	
Valley Underflow	1.5	
River Seepage	1.3	
Precipitation	0.8	
	<u>Total - 8.7</u>	
Springs and Rivers		7.1
Irrigation Pumping		1.6
		<u>Total - 8.7</u>

0.2. Estimates of the porosity of the aquifer range from 5 to 15% (Hull, 1986).

Average horizontal flow rates in the aquifer are difficult to assess. Because the aquifer is made up of an interbedded sequence of basaltic lava flows and sedimentary deposits, flow rates differ both horizontally and vertically within the aquifer. The tops of basalt lava flows are highly permeable, and water moves primarily along these layers. Occasional lava tubes may fill and convey water rapidly for short distances. Some of the sedimentary stratum are coarse grained and will store and transmit significant quantities of water. Flow rates in the aquifer have been estimated from flow net analysis to be 5-20 feet per day, (Robertson, et al., 1974), with an average near 10 feet per day.

There is a very thick unsaturated zone at the INEL which ranges from approximately 200 to 1000 feet thick. This zone is a complex sequence of basalt flows, breccia zones, and sedimentary interbeds. Water from the surface percolates downward until it reaches an impediment, be it a dense basalt flow, sedimentary interbed or sediment infilling in a fractured basalt flow. If the impediment is poorly permeable and causes a perched-water body to form, flow in the unsaturated zone underlying the base of the perched zone will be continuous until saturation in the perched zone is depleted and is drained to the point of specific retention. The quantities and rates of movement of this water are unknown. In areas of major surface recharge where large quantities of water move downward through the unsaturated zone, water infiltrating the surface moves downward until it reaches the interface between the surficial sediments and the basalt. The cross sectional area available for flow decreases at the basalt interface since the basalt has a very low porosity (<2%) compared to the overlying sediments (40%-50%). The fractures and vesicles in the basalt at the interface are frequently plugged with fine grained materials and secondary calcite. As a result, the interface represents a low permeability layer which impedes the downward flow of water. A small perched water zone develops on this interface under most liquid waste disposal facilities and recharge zones (Morris, et al., 1963; Morris, et al., 1965; Robertson, et al., 1974). Once the water enters the basalt, it percolates downward and spreads laterally. Lateral movement is due to the tortuous path the water must follow as it moves downward through sequential basalt flows. As water moves downward it may encounter additional sedimentary layers which may or may not be less permeable than the basalt. Where the sedimentary interbeds are less permeable than the basalt, additional perched water zones may be formed. If the layer is more permeable than the basalt, water will continue to percolate downward. The water continues to move downward until it reaches the regional aquifer.

G.1.2 Snake River Plain Aquifer at the INEL

The Snake River Plain Aquifer beneath the INEL is characteristic of the aquifer in general. Figure G-2 shows the location of wells.* Figure G-3 maps contours on the regional water table and includes inferred directions of flow. Flow lines concur with general flow data and reveal a net groundwater movement from the north-northeast to the south-southwest. The average gradient within the INEL is about five feet per mile to the south-southwest. Figure G-4 illustrates the depth to the water table from the land surface at the INEL. Depth varies from 200 feet in the northeast corner to 900 feet in the southwest corner. Depth to the water table at the Argonne-West Site is approximately 630 feet.

The Snake River Plain aquifer is composed of a large stratified water body extending down 700 to 1,500 feet. At INEL 1, the sediment from 850 to 950 feet may impede water movement but the basalts from 960 to 1,220 feet appear to be adequate to yield sizeable quantities of water. Below 1,220 feet are the poorly permeable sedimentary interbeds to 1,540 feet, and then the altered and mineralized basalts to 2,170 feet together which form a base for the aquifer.

This base or semi-confining layer may lie approximately 700 to 1,500 feet below the land surface. Well log data indicates the presence of silt, sand, and clay beds at this location which could act as the lower confining layer to the aquifer even though water is present at much greater depths. These layers are assumed to be relatively intact at varying depths from 700 to 1,500 feet throughout the area of the INEL and have been encountered in other test wells (Mann, 1986). Consequently, this depth will be considered as the effective base of the aquifer. This zone of the aquifer exhibits an isotropic-like properties, in that not all of the effective thickness participates in the active flow system. Based on a mass balance of tritium

* Numerous other numerous wells exist in the Test Reactor and Chemical Processing Plant Area just south of well No. 98 (See Fig. 4 of Pittman, et al., 1988).

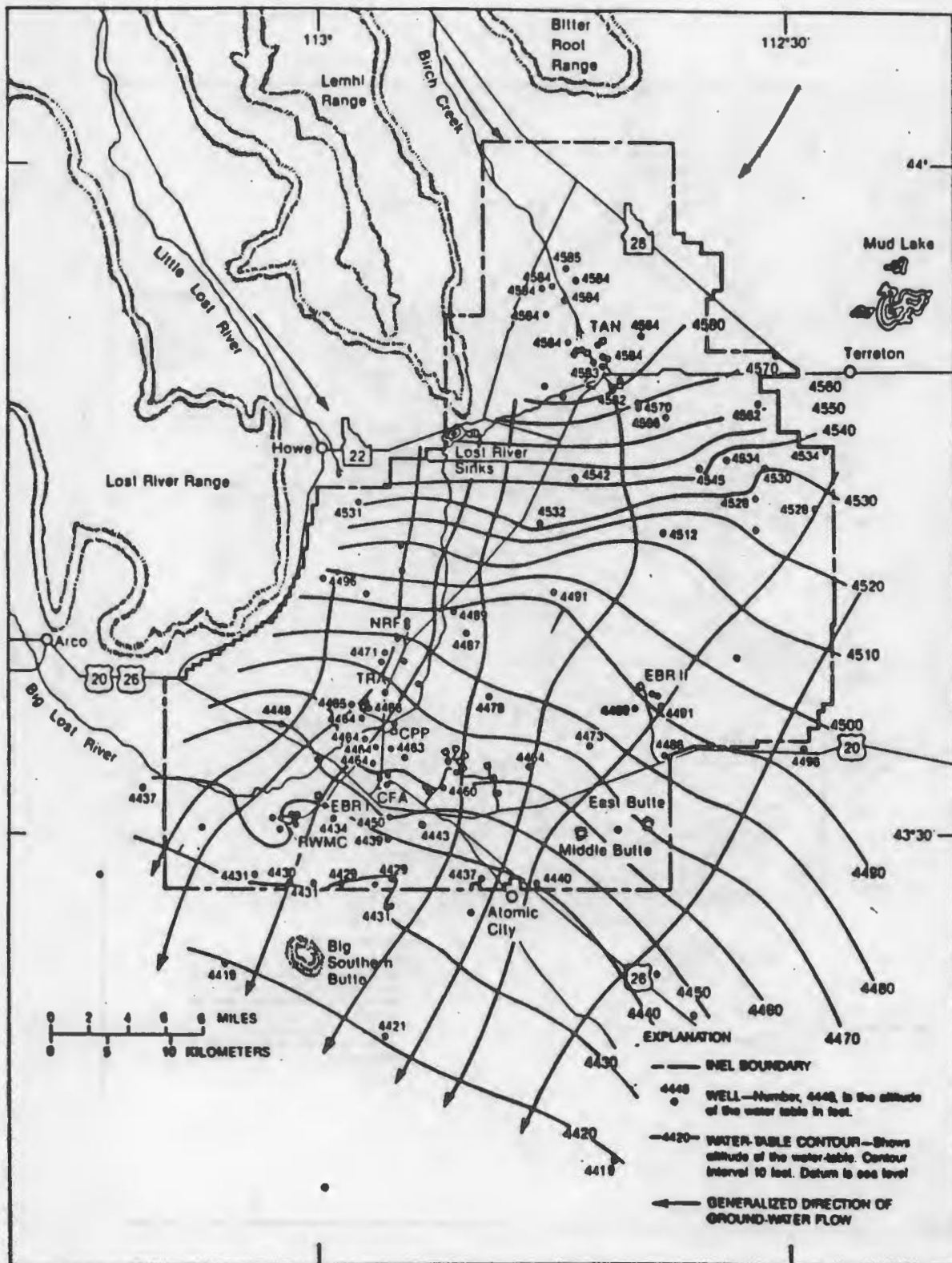


Figure G-3
Altitude Contours on the Regional Water
Table and Inferred Directions of Ground-water
Movement, INEL and Vicinity (Pittman, et al., 1988)



Figure G-4
Approximate INEL Water Table Contour Map Illustrating Depth
to the Regional Water Table Flow (Barracough, Lewis, and
Jensen, 1981)

disposal from INEL facilities, it was concluded that only the upper 250 feet of the aquifer system interacts with disposed wastes (Schmalz and Polzer, 1969).

Aquifer use at the INEL is restricted to production wells which provide drinking water and process water for reactor and fuel processing operations. In 1984 the wells pumped 6,000 acre feet of water. The only significant natural recharge to the aquifer at the INEL is from the Big Lost River. However, small amounts of recharge also occur from the infiltration of the Little Lost River, Birch Creek, and precipitation (during spring runoff). The average annual flow of the three streams is approximately 315,000 acre-feet per year which is much greater than the 6,000 acre feet withdrawn by the production wells. The amount of precipitation which is not lost to evaporation and becomes recharged is not known. Potentially, this recharge rivals that of stream flow. Based on a surface area of 572,000 acres and an annual precipitation rate of nine inches per year, around 400,000 acre-feet of water is deposited on the INEL each year. Most of the precipitation is snow which melts in the spring of each year producing runoff that accumulates in depressions in the basalt. These small ponds produce significant volumes of local recharge. In areas of thick soil cover, very little recharge probably occurs. A study conducted at the INEL using a tritium mass-balance in the soil indicated that during the period from 1951 to 1965, 96.5% of precipitation was evapotranspired. The remaining 3.5% remained in the upper 80 inches of the soil and presumably would eventually become recharge amounting to 14,000 acre feet per year. Under these conditions and on this type of soil, little water would be available for leaching and transporting solutes through the unsaturated zone (Schmalz and Polzer, 1969). Man-influenced recharge through the use of waste disposal operations at different facilities also comprises a significant portion of the water mass balance at the INEL. In 1984, approximately 1.3 billion gallons (4,000 acre feet) of water were returned to the groundwater system through waste disposal activities (IWMIS, 1984). This represents approximately 60% of all withdrawals. The remaining water was consumed by evaporation or transpiration to the atmosphere. Water table levels in the aquifer at the INEL fluctuate in response to rainfall, snow melt, stream flow, and water use. An overall decrease in the water table level occurred from 1973 to 1981 (Lewis and

Jensen, 1984). This decrease does not appear to be related to activities at the INEL but follows trends as previously reported on the aquifer in general. A net rise was recorded from 1981 to 1985 (Pittman, et al., 1988), and in 1985, water levels were at their highest since detailed records were kept beginning in the 1950's. (Verbal Communication, L. J. Mann, USGS)

Transmissivities differ with location at the INEL. Pumping tests indicate values ranging from 4,000 feet squared per day at the northern end of the site to 2.4 million feet squared per day near the southwestern corner of the site (Walker, 1960). A typical transmissivity value for the INEL might be 300,000 feet squared per day. Storage coefficients range from 0.01 to 0.06 (Walton, 1958; Walker, 1960). The average porosity of the aquifer at the INEL is approximately 8 to 10% (Hull, 1986). Transmissivity contours over the INEL are shown in Fig. G-5 in units of feet squared per second. The transmissivity in feet squared per second corresponding to the above are a range of 0.05 to 28 and average of 3.5.

Assuming an average transmissivity of 300,000 feet squared per day, average hydraulic gradient of five feet per mile, effective aquifer thickness of 250 feet (minimum), and average porosity of 10% (maximum) yields a flow rate velocity of 11 feet per day on the net pore area. (Hull, 1986). This is equivalent to a velocity of 1 to 1-1/2 feet per day on the gross area. This value agrees well with the range of values presented by Robertson, et al. (1974). Direct measurements of flow rate velocities have been made at the INEL by tracing the travel time of tritium peaks between wells. Values ranging from 11 to 20 feet per day were calculated from wells near the Chemical Processing Plant (Barracough, et al., 1967). These are somewhat higher than the above calculated values.

Vertical flow is not expected to occur at the INEL except in localized areas of significant recharge where water infiltrates the ground surface and percolates downward toward the aquifer. Layers of fine grained sediment with low permeability retard downward percolation forming perched water bodies beneath the recharge area. Perched groundwater is present at the INEL and is expected to occur in areas surrounding the Big Lost River, areas which drain significant volumes of spring run-off (closed basins), and areas beneath waste

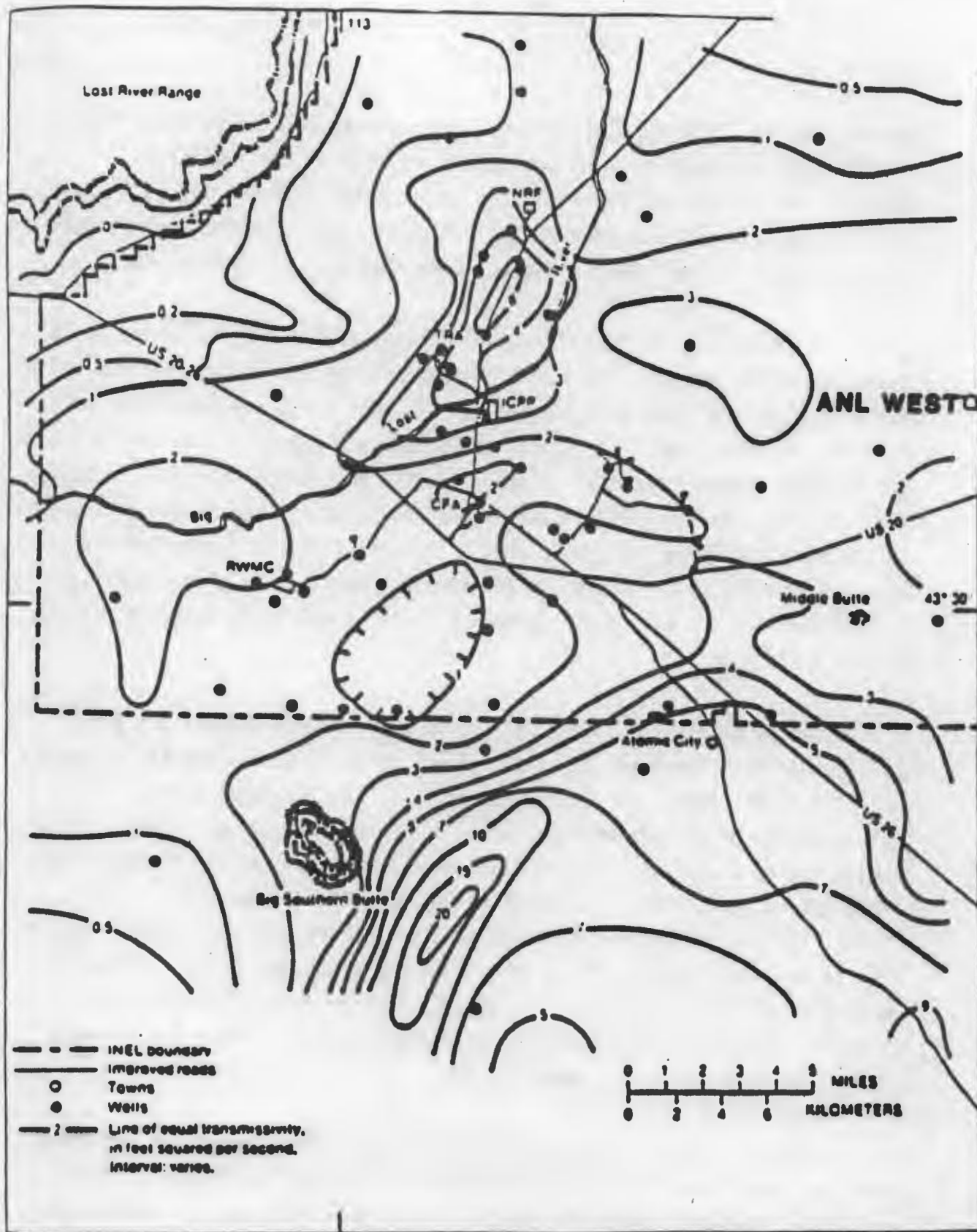


Fig. G-5. Generalized Transmissivity Contours for the Snake River Plain Aquifer, Southwestern INEL and Vicinity (Robertson, 1974)

disposal units. The general stratigraphy indicates the presence of numerous stratum above the water table, which could act to perch water. In 1977 a model was developed to calculate vertical flow velocities associated with the long term effects of seepage basin use at the INEL Test Reactor Area (TRA). Velocities were calculated for surficial sediments and for deep basalts. The range in velocity for the deep basalt was dependent upon the relative thickness of the perched water body. At a flow rate of two feet per day water could reach the aquifer in 225 days (Robertson, 1977). This calculated value is consistent with the movement of radionuclides from the same seepage basins. These velocities are only valid for situations where water is present on the surface for long enough periods for the entire saturated zone to come to equilibrium with the applied moisture. As such the projected value represents the absolute maximum value that can be expected for flow through the saturated zone at the INEL.

It is frequently possible to relate the composition of groundwater with the minerals and rocks in contact with the water. The geologic history of the Snake River Plain indicates the presence of a variety of materials which could influence background levels of compounds present in the groundwater at the INEL. Table G-2 depicts groundwater constituent concentrations from different areas surrounding the Snake River Plain which contribute to the aquifer. This information is helpful in establishing overall ranges of groundwater constituent concentrations which could be encountered in groundwater samples obtained at the INEL. Although few samples were collected and evaluated, the data presented is a good approximation of the composition of groundwater beneath the INEL prior to waste disposal activities in 1951.

G.1.3 Local ANL-W Groundwater Hydrology

Data from wells operating at the Argonne-West Site indicate that the Snake River Plain aquifer water table is located approximately 630 feet below the ground surface. Water level measurements made from 1957 to 1983 show that the depth to water at well site 16 has fluctuated about 6 feet.

TABLE G-2
Groundwater Composition of the Snake River Plain Aquifer at
Outlying Recharge Source Areas (Robertson, et al., 1974)

Constituent	Concentration (mg/l)				
	North	Northwest	Northeast	East	Average
Temperature (F)	52	55	54	49	53
pH (Units)	7.7	7.6	7.4	7.8	7.6
Spec. Conductance	963	489	194	444	523
TDS	583	289	140	270	321
Calcium	93	67	18	56	59
Magnesium	33	18	5.8	16	18
Sodium	42	9	15	14	20
Potassium	6.8	1.8	2.4	2.2	3.3
Bicarbonate	186	274	102	179	185
Carbonate	0	0	0	0	0
Sulfate	57	24	4.9	63	37
Chloride	160	7.5	7.5	16	48
Nitrate	2.9	1.7	1.4	0.2	1.6
Fluoride	0.3	0.3	2.0	0.3	0.7
Silica	29	24	40	6.4	25

In 1984 through 1986 Argonne-West withdrew an average of 150 million gallons of water per year from the aquifer. The principle uses for the water were associated with plant operation and potable water. It is estimated that approximately 35 million gallons per year of wastewater representing one quarter of the volume removed from the aquifer was disposed of to the Industrial Waste Pond, and perhaps 3 to 4 million gallons of this discharge was drained through the north ditch.

The draw down has varied significantly from pump tests at the Argonne-West production wells but the data are useful in deriving a range of

transmissivity values for the underlying aquifer. Results may be lower than average INEL values but are within the range expected. A transmissivity range of 30,000 to 1.4 million feet squared per day may be calculated from the available data from the two production wells. This large difference in transmissivity is not uncommon in other tests in small areas on the Snake River Plain. The average transmissivity for the area is then perhaps 300,000 to 500,000 ft squared per day, which agrees quite well with generalized transmissivity contours for the INEL (Robertson, 1974). The average gradient on the water table may be estimated as approximately two feet per mile. Based on an effective aquifer thickness of 250 feet, groundwater velocity may range up to 2 feet per day on the gross area. Data expressing the rate of vertical flow in the aquifer system near the area is not available.

Since the occurrence of geologic materials varies spatially throughout the INEL, concentrations of compounds in the groundwater used for comparative purposes must be obtained from areas relatively close to the facility in question. Investigations and interpretations (Northern, 1988) have been made during and following the drilling of five shallow boreholes and one deeper borehole adjacent to the industrial waste pond at Argonne National Laboratory - West during the fall of 1987. The information gathered from the borehole investigation program and existing information compiled from previous investigations was used to characterize the subsurface geology and hydrogeology underlying the pond. The results are summarized in appendix H. In addition, the analytical results of the pond water-quality samples were evaluated.

The targeted sedimentary interbed occurring at an approximate depth of 40 to 50 feet below the ground surface is not areally extensive and is noticeably absent west of the industrial waste pond. The thickness of the interbed varies from zero to 6.5 feet. The interbed is present in boreholes ANL-M1, ANL-M2, and ANL-M3. The interbed does not perch water and is considered a leaking aquitard.

Several factors are believed to combine to account for the absence of a perched water body: (1) the discharge volume from the ANL-W facility to the industrial waste pond is relatively small and intermittent; (2) the grain size of the sedimentary interbeds is not sufficiently fine to inhibit vertical

flow; and (3) the interbeds underlying the pond are relatively thin (6.5 feet) as compared to other areas on the INEL where perched aquifers (30 feet) are present. Although the industrial waste pond always contains water, the intermittent discharge of blowdown water to the pond may create transient conditions that lead to the formation of a temporary saturated zone beneath the pond.

Cation percentages are quite similar between the IWP and ANL-M5 water samples, and the nearly equivalent concentration of dissolved solids of the two samples suggests that the shallow groundwater is probably derived from the downward seepage of industrial waste pond water.

G.2 Surface Water Hydrology*

The occurrence of surface water at the INEL is mainly that of streams draining the mountains and valleys to the west and north. Localized snowmelt and rain also contribute to surface water especially in the spring.

Water from the Big Lost River, Little Lost River, and Birch Creek enters the INEL during wet years. Most of the flow from the Little Lost River and Birch Creek is diverted for irrigation before it reaches the INEL.

The Big Lost River is the INEL's most important source of surface water. Recharge to the Snake River Plain Aquifer from the Big Lost River during wet seasons has been significant and all of the flow onto the plain from the river, except for transpiration/evaporation losses, is recharged to the subsurface and the underlying aquifer system. The river has developed an extensive flood plain of alluvial materials. During wet years the Big Lost River flows southeastward down the Big Lost River valley past Arco, and onto the Eastern Snake River Plain. After entering the plain the river turns northward through the INEL to its termination in the Lost River "sinks" or terminal playas. As flow approaches the terminal playas, the channel branches

* (Ref: ANL-W, 1989)

into many tributaries and flow spreads over several flooding and ponding areas. (Barraclough, 1967).

In addition to irrigation diversions, artificial controls effect the flow of the river onto the plain. These are the Mackay dam, 30 miles upstream from Arco, and the INEL flood control diversions system in the southwestern part of the INEL. The diversions system was constructed in 1958 to reduce the threat of floods from the Big Lost River. The system is designed to divert flood waters into a series of four spreading areas. During winter months all flow reaching the INEL is diverted at the diversion facility to avoid accumulation of ice in the main channel and consequent flooding downstream near INEL test facilities (Lewis and Jensen 1984).

The average annual flow from the Big Lost River calculated over a 62 year period is approximately 210,000 acre-feet. During the peak run-off years, annual flows approach values of almost 400,000 acre-feet. During dry years annual flows are measured at less than 100,000 acre-feet. During high run-off years flow rates in the river channel at the INEL measure up to the 900 cubic feet per second, the capacity of the culverts at the diversion dam and carry almost 88,000 acre-feet of water onto the INEL. Since the River is a primary aquifer recharge mechanism, high flows onto the INEL trigger a rise in the aquifer water table. The water level in a well adjacent to the river which tapped a perched water zone has risen as much as 100 feet within a period of one week in response to increased flow rates onto the INEL. The water level in well 12 near the NRF rose nearly 21 feet over an eight year period of high flow rates. In general, the closer a well is to the surface water source the greater the response to increased surface run-off rates (Lewis and Jensen, 1984).

Precipitation also occurs at the INEL and accounts for some recharge to the aquifer on a seasonal basis. The average annual precipitation rate at the INEL is 9.07 inches. Yearly totals may range from high values of 14.4 inches to low values of 4.42 inches. The maximum observed 24 hour precipitation amounts are less than 2.0 in. The maximum one hour amount is recorded at approximately one inch of water. About 26 inches of snow falls each year at the INEL. The maximum yearly snowfall is 41 inches while the

minimum value was measured at only 11 inches. The ground is usually free of snow from April to November. During rapid snow melt in the spring substantial recharge to the aquifer can occur especially in closed basin areas. The Snake River Plain is an arid area. Although precipitation occurs on a periodic basis, the evaporation rate is nearly 29 inches per year. In consideration of evapotranspiration, the overall net precipitation at the INEL is at least minus 20 inches (NRF* CERCLA Report, 1986).

* Naval Reactors Facility (INEL)

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APPENDIX H

ANL-W INDUSTRIAL WASTE POND AND DITCHES

H.1. HISTORY AND PRESENT STATUS*

The ANL-W Industrial Waste Pond (IWP) at ANL-West is an unlined evaporative seepage pond excavated in 1959. The three acre pond originally contained a water depth of about 4 meters (13 ft.), and an area of about three acres, and is fed from four industrial waste water ditches. The pond overflows to the desert area north of the pond. The primary continuous flow into the pond has been the EBR-II main and auxiliary cooling tower blowdown flow and a secondary continuous cooling water flow from other ANL-W facilities via the North Ditch. One of the four main ditches leading into the pond is the accumulated drainage from storm water or spring runoff water from the ANL-W site and nearby terrain surface. The present route of flow from HFEF/S into the pond is shown in Fig. H-1, and the pond outline is shown in Fig. H-2. Figure H-3A shows (and labels) the network of surface ditches that drain into the IWP. Figure H-3B gives a better overall view. The present type and location of discharges into the ditch network are shown in Table H-1. The HFEF/S Industrial Waste Water discharges into upper end of the ditch labeled A-A1 in Fig. H-3A. This ditch was constructed with a backhoe between 1970 and 1975 and is unlined. The amount of sediment in the ditch ranges from zero to several inches because of the changing rock depth underlying the ditch. The depth of the ditch varies from 1-3 feet. In the past, cooling tower blowdown water entered the ditch at Point A. This water was rerouted after a short period of time,* but traces of chromates remain in the ditch. The total (all ANL-W) volume of water discharged to the pond ranges from 1.42 to 4.22 million gallons per month with an average discharge rate of 31.7 million gallons per year (87,000 gallons per day) as measured from July 1977 to June 1978 (CH₂M Hill, 1978). Another investigation determined that the ANL-W site discharged approximately 23.7 million gallons per year from 1961 to 1970. These volumes are relatively low in comparison to the amount of water discharged at the Test Reactor Area (TRA) and the Idaho Chemical Processing Plant (ICPP). The volume discharged to the pond at the TRA ranged from 7 million to 30 million gallons

*Ref: Villarreal 1986, and Northern 1988

Figure H-1

Industrial Waste Route from HFEF/S

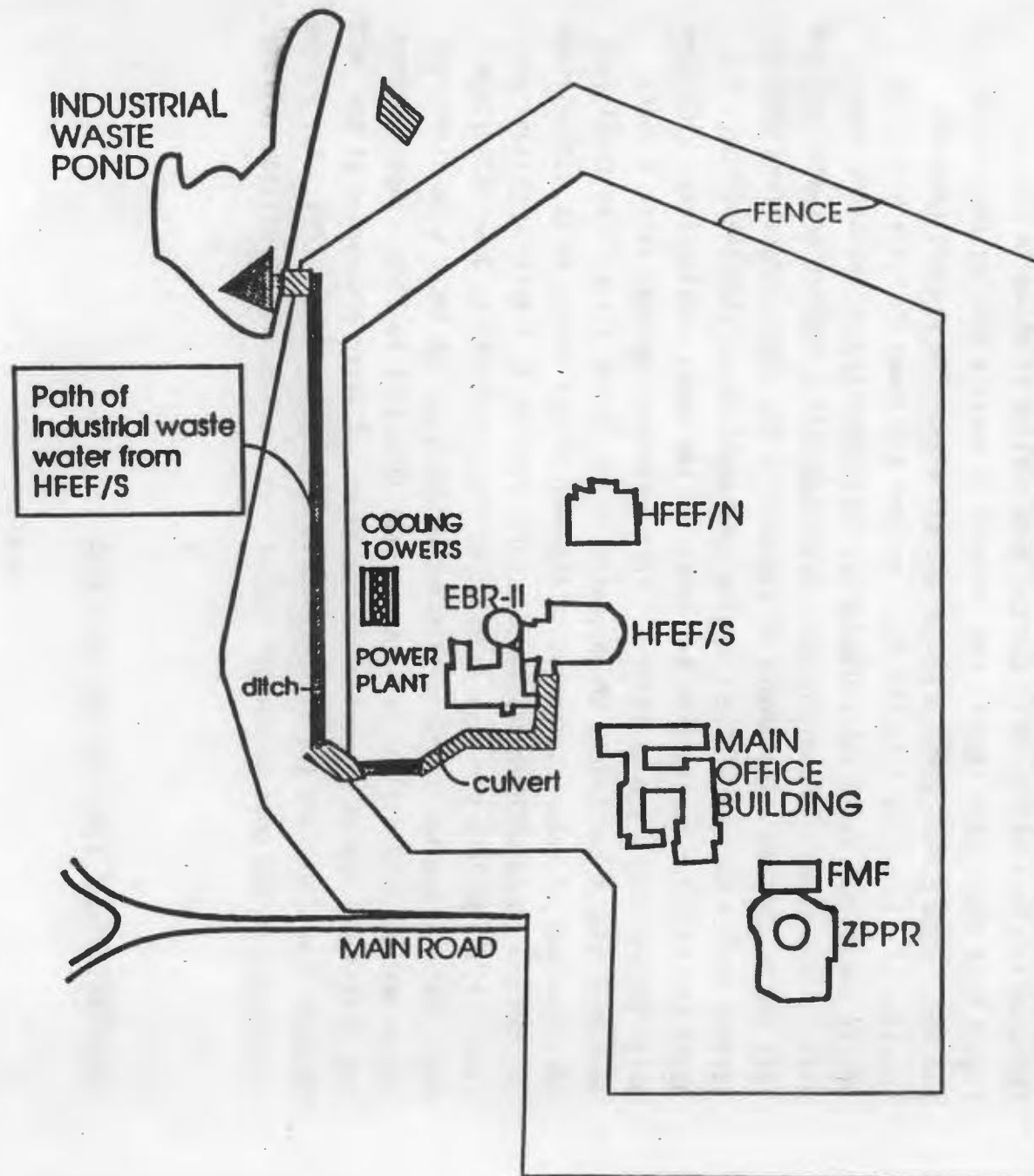
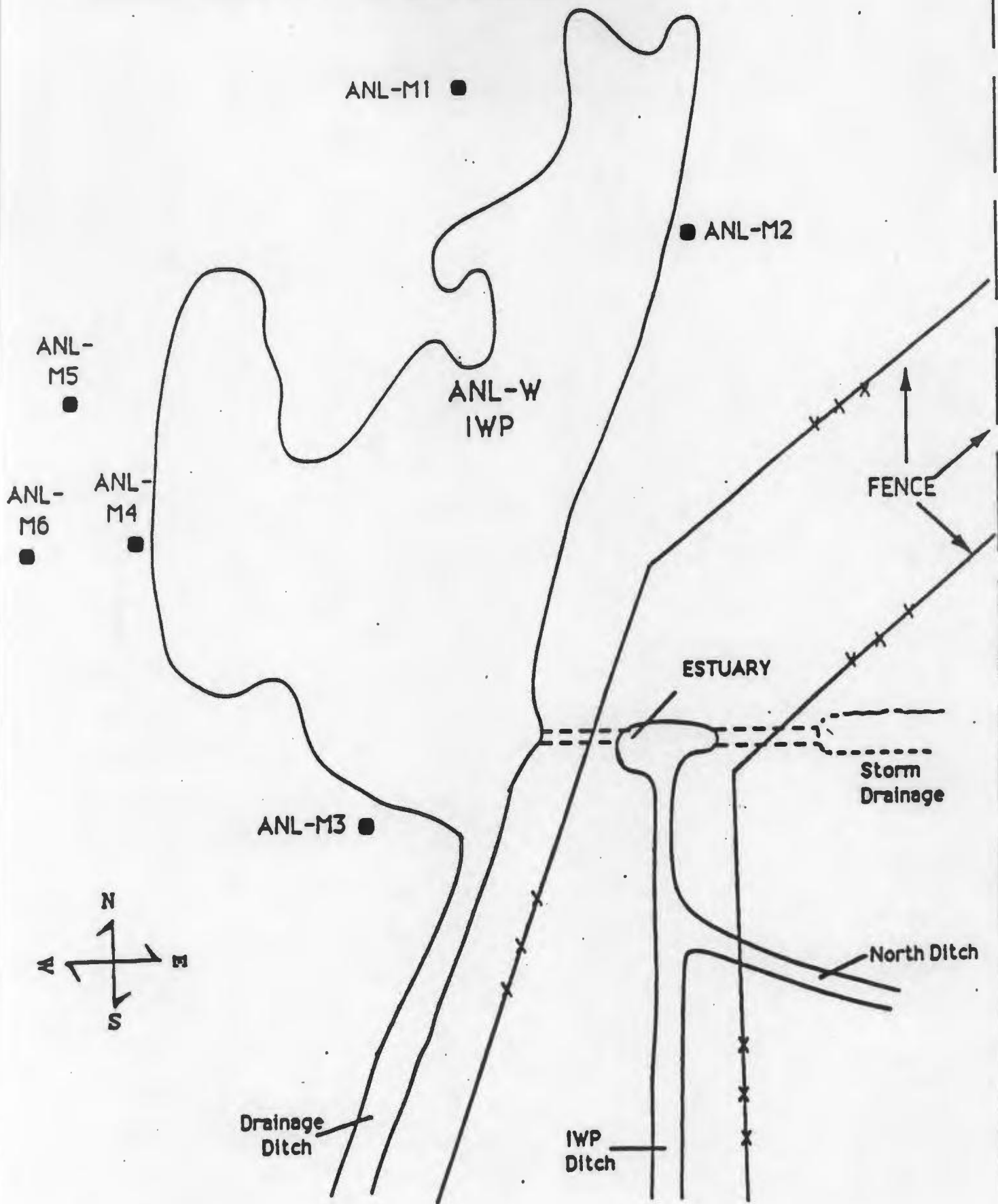
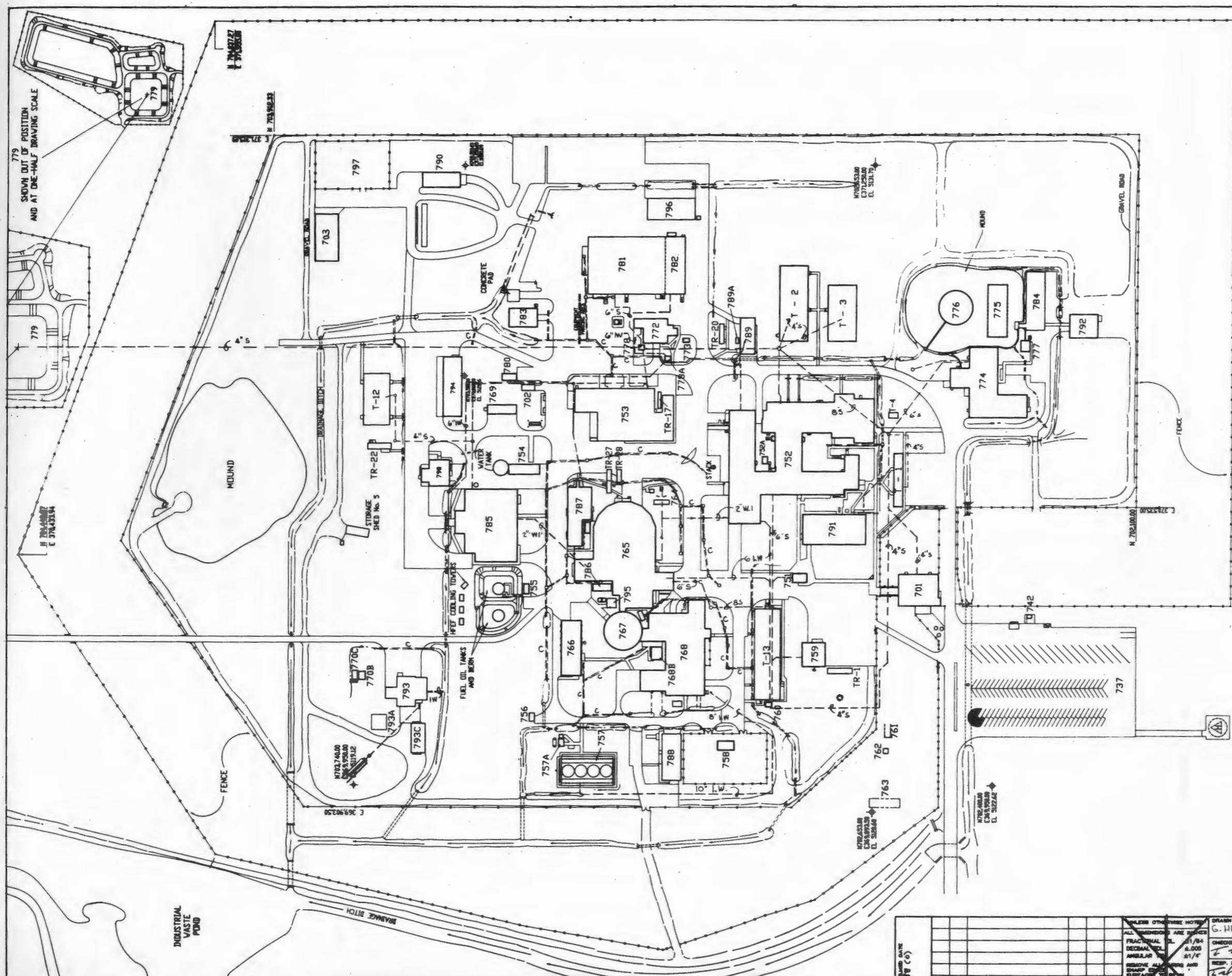


Figure H-2

Industrial Waste Pond with Borehole Locations





- REFERENCE DRAWINGS**
- W7380-0004-EE-07 SITE PLAN PERIMETER FENCE SHEETS 1 THRU 17
 - W0170-4075-ED- NORTH RADIOGRAPHY STATION HFEF/N - SHEET 2
 - W7930-0125-ED-02 CONTAMINATED STORAGE AND RESTROOM FACILITY - BLDG 703 SHEET N-7
 - W7500-0112-ED-02 POWER PLANT INDUSTRIAL WASTE LINE MODIFICATIONS
 - W7530-0103-ED-00 PLANT SERVICES ADDITION - BLDG. 753
 - W7010-0004-ED-00 SECURITY BUILDING - BLDG 701 SHEET C-2
 - W7980-0104-ED-11 RL.W.T.F. BUILDING 735 - DRAINAGE & GRADING PLAN - SHEET 3
 - W7500-4001-DD-08 ANL-W TOPOGRAPHY NORTH 1/2 SHEET 6
 - W7500-0266-ED-01 SITE PREPARATION FOR TECHNICAL ELDS: T-1 - T-3 SHEET 1

Fig. H-3B. Industrial Waste System in ANL-W setting (Note that HFEF/S IW line no longer runs under T-13, see Fig. H-1).

TABLE H-1
Discharges to Industrial Waste Ditches*

Building	Source	Type of Waste Water	Industrial Waste Ditch
768-Aux. Boiler	Roof Drains (3)	Rain Water	A-A1
768-Aux. Boiler	Deaerator Tank Drain	Feedwater	A-A1
768-Aux. Boiler	Sample Cooler	Raw Water	A-A1
768-Aux. Boiler	Feedwater Pump Bearing Cooling Water	Raw Water	A-A1
768-Aux. Boiler	Feedwater Pumps Shaft Seal Leakage	Feedwater	A-A1
768-Aux. Boiler	Condensate Storage Tank Drain and Overflow	Condensate	A-A1
768-Aux. Boiler	Electric Feedwater Heater Drain	Feedwater	A-A1
768-Aux. Boiler	Boiler Blowdown	Feedwater	A-A1
768-Aux. Boiler	Boiler Drains	Feedwater	A-A1
768-Aux. Boiler	Condensate Drains	Feedwater	A-A1
768-Aux. Boiler	Roof Evaporator Cooler	Raw Water	A-A1
768-Power Plant	Roof Drain	Rain Water	D-D1
768-Power Plant	Condensate Storage Tank Overflow	Steam Condensate	D-D1
768 Power Plant	Roof Drain & Feedwater Heater (3 & 4) Safety Valve Relief	Rain and Condensate Water	D-D1
768-Power Plant	Hotwell Drain	Steam Condensate	D-D1

H.6

* Ref: ANL-W, 1989.

TABLE H-1 cont.

Building	Source	Type of Waste Water	Waste Ditch
768-Power Plant	Roof Drain	Rain Water & Auxiliary Cooling Tower Leakage	D-D1
768-Power Plant	Auxiliary Cooling Tower Overflow	Auxiliary Cooling Water	D-D1
768-Power Plant	Auxiliary Cooling Tower Basin Drain	Auxiliary Cooling Water	D-D1
768-Power Plant	Primary Pump Motor-Generator Set Clutch Sump Overflow and Roof Drain	Auxiliary Cooling Water and Rain Water	D-D1
766-Sodium Boiler Bldg.	Hotwell Drain	Steam Condensate	D-D1
766-Sodium Boiler Bldg.	Dowtherm Pump Gland Leakoff	Auxiliary Cooling Water	D-D1
766-Sodium Boiler Bldg.	Steam System Water Dump Tank	Steam Condensate	E-E1
757-A Main Cooling Acid Shack	Acid Shack Eductor Water and the Eye Wash & Safety Shower	Raw Water	C-C1
757-Main Cooling Tower Valve Pit	Leakage from Valve Pit	Raw Water	C-C1
757-Main Cooling Towers	Cooling Tower Deluge Test Line	Raw Water	C-C1
757-Main Cooling Tower	Basin Drains (2)	Main Cooling Tower Water	B-B1
765-HFEF/S	Building Air Supply Washer Drain	Raw Water	A-A1
765-HFEF/S	Drinking Fountain	Raw Water	A-A1

TABLE H-1 cont.

<u>Building</u>	<u>Source</u>	<u>Type of Waste Water</u>	<u>Waste Ditch</u>
765-HFEF/S	Back Flow Preventer	Raw Water	A-A1
765-HFEF/S	Plant Air Compressor Drains	EBR-II Aux. Cooling Water	A-A1
765-HFEF/S	Compressor-After Cooler	EBR-II Aux. Cooling Water	A-A1
765-HFEF/S	Truck Lock Floor Drain	Raw Water	A-A1
765-HFEF/S	Janitor Sink Drain	Raw Water	A-A1
765-HFEF/S	FASB Building #787 (Closed Loop Coolers and Drinking Fountain)	Raw Water	A-A1
785-HFEF/N	Met Lab Drain Tank	Demineralized Water	F-F1
785-HFEF/N	Sump #1	Raw Water and Condensed Moisture	F-F1
785-HFEF/N	Sump #2	Raw, Demineralized, HFEF/N Aux. Cooling Tower Water and EBR-II Steam Condensate	F-F1
785-HFEF/N	Sump #3	Raw Water and Photo Lab. Solutions	F-F1

per month and has averaged about 190 million gallons per year. A disposal well was used to inject approximately 300 million gallons per year of waste water at the ICPP (Robertson and others, 1974). NOTE: This injection was terminated in February 1984. The water now goes to an infiltration pond. (Ref: verbal communication, R. Mitchell, DOE-ID, 1990).

Discharge from the Snake River Plain Aquifer at the ANL-W facility is dominantly a result of well pumpage and evaporation and exfiltration in the vicinity of the facility. Total monthly well production at the facility ranged from 6.65 to 16.42 million gallons during July 1977 to June 1978 with an annual production rate of 135 million gallons. Soil exfiltration, evaporation, and evapotranspiration from foliage account for an unquantified amount of discharge.

The outside perimeter of the pond down to the littoral zone supports a variety of plant life during the spring and summer months, especially emergent cattails. Moss and several species of algae give the pond a greenish color during the late summer and fall months when dispersed moss makes the water quite turbid. There is a profusion of aquatic insects in the water and a view of the water under a microscope reveals quite a variety of microorganisms, however the population of microorganisms increases rather dramatically when a water extract of the pond sediments is examined. A family of 10-12 ducks seem to thrive and multiply each year on the pond but the population is limited by the coyotes, eagles, and hawks which prey on the younger ducklings.

The primary sources of liquid waste discharged to the pond are from the EBR-II cooling towers and from the EBR-II steam system pressure relief valves (blowdown). A secondary source of liquid waste is from the overall site water coolant systems. The primary source of impurities channeled into the pond are from natural sources, namely, runoff waters from storms in the summertime and melting snow in the spring, and silt material blown in during frequent windstorms. The runoff water transports finely divided silt to the pond with much organic material that varies from sagebrush leaves, grass, lichen and desert plants to droppings from deer, antelope, rabbits and other

desert mammals. A quasi-continuous stream of excretion is injected into the pond by the duck population.

The main source of impurities discharged (in 1986) as industrial waste into the pond were chemicals for water treatment and for regeneration of ion-exchange resins as listed in Table H-2.

TABLE H-2
Water Treatment Chemicals Used in EBR-II

Slimicides	Biocides
Betz C-30	Chlorine gas
Betz J-12	
Corrosion Inhibitors	Ion Exchange Regeneration
Beta 2020-2040	H ₂ SO ₄
Nalco 7270	NaOH
Nalco Elim-OX O ₂ Scavenger	

Also, the pond presently receives effluents from photographic processing after the silver has been removed. For different periods of time in the past, several water treatment chemicals were discharged to the ANL-W Industrial Waste Pond including sodium chromate, bleach, dimethylamine, sulfur dioxide, hydrazine, morpholine, and photographic processing waste containing silver. Generally, these chemicals were discharged at concentrations in the low part per million range.

The ANL-W IWP ditches and the IWP were classified as a Land Disposal Unit (LDU) late in 1986 when the pH of the effluents from regeneration of ion-exchange columns was measured to be as low as pH 1.58 upon discharge to the IWP ditch which exceeded the EPA limits of Ph >2.0 and <12.5 specified in 40 CRP 261.22. Although the pH of the effluents was not in compliance for only a

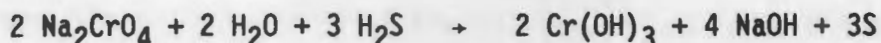
short time, and installation of an Industrial Waste Neutralization tank terminated the acidic effluents, the IWP ditch and IWP were classified as a single unit LDU. EPA also had a secondary concern about residual chromates in the IWP and IWP sediments from discharges containing chromates in previous years.

Chromium is a complex element which occurs in several oxidation states; however, the trivalent state (Cr III) is most common in nature. The hexavalent state (Cr VI), the highest oxidation state of chromium, was used in the cooling tower water to inhibit corrosion within the system. Hexavalent chromium is more toxic than the trivalent form because of its oxidizing potential and ease in penetrating biological membranes (Taylor and Parr, 1978). EPA includes hexavalent chromium on the hazardous constituents list because it is a systemic poison.

Trivalent chromium is the most stable oxidation state of chromium and therefore would be the species that would accumulate in the carbon-rich upper sediment layer. In this reduced state, trivalent chromium is relatively inert (Taylor and Parr, 1978). Because trivalent chromium compounds are extremely insoluble and poorly absorbed by biota, they are considered biologically insignificant (National Academy of Sciences, 1974).

An ANL-W study of the chemistry of the pond, according to EPA approved methods, showed that chromates were not present in the pond water or the sediments and further that thermodynamically chromates could not exist in the pond environment. Experiments conducted with the pond sediment and the pond water showed that any discharge of hexavalent chromium to the pond would be irreversibly reduced to Cr(III) in a few hours. The high pH of the pond (pH seasonally varies from 8.9 to 11.0) is due to the extremely basic soil containing the pond and surrounding the pond. The natural seasonal cycles on the environment provides the greatest impact on the chemistry of the pond and natural eutrophication creates a reducing environment in the pond. With the existing limnology of the pond, the mutual existence of chromates with the pond water or the pond sediments is not possible.

The continual replenishment of organic material in the pond especially during spring runoff and the subsequent natural eutrophication of the pond sediments with production of H_2S and other reducing agents accelerates reduction of $Cr(VI)$ as in the reaction:



Barlett and Kimble 1976) found that $Cr(VI)$ was rapidly reduced by soil containing organic material and that the reaction was irreversible. Schroeder and Lee (1975) have shown that the oxidation of $Cr(III)$ to $Cr(VI)$ in natural waters in the presence of dissolved oxygen is very inefficient and that the presence of $Fe(II)$, dissolved sulfides, and certain organic compounds makes the reaction irreversible toward the $Cr(III)$ end of the reaction.

Since organic material is continuously replenished in the Industrial Waste Pond which is essentially a closed system, the natural eutrophication of the organic matter generates reducing agents that effectively and irreversibly convert $Cr(VI)$ to $Cr(III)$. The irreversible reduction of $Cr(VI)$ rapidly depletes the $Cr(VI)$ concentration in the pond water and sediment. Because of environmental considerations, chromates are no longer discharged to the pond. Therefore, $Cr(VI)$ does not presently exist in the pond water and sediment. Many water and sediment samples were taken from the ANL-W Industrial Waste Pond to demonstrate this fact.

A study of the elemental concentrations of EPA toxic metals was also conducted and concluded that the IWP water and sediments did not contain extractable toxic elements. Metallic ions that are discharged to the IWP are immediately complexed by anions that form highly insoluble precipitates that are concentrated at the inlet to the pond. With time, the precipitated metal species are metastasized to precipitates with higher stability constants. An uneven distribution of precipitated metal species results in the sediments from the inlet to the outlet of the ANL-W Industrial Waste Pond. Sediment samples taken from different locations and depths in the ANL-W Industrial Waste Pond and analyzed for total Cr, Ag, Pb, Cd, and Ba by method 1310 for EP toxicity, show that these metals are generally <1% of the established EPA limits. The natural chemistry of the pond, the generation of sulfides by

sulfate-reducing bacteria and natural eutrophication of organic containing sediments, increase the concentration of anions that form insoluble complexes which fix the metal species in an uneven distribution in the sediments from the inlet to the outlet of the pond. The high basic Ph of the pond combined with high concentrations of sulfates, chloride, and phosphates leads to near immediate conversion of Cr, Ag, Pb, Cd and Ba to insoluble compounds.

The results from the studies of the IWP prompted ANL to separate the ditch, estuary, and the Industrial Waste Pond into two units since it became obvious that slightly acidic regenerant discharges were neutralized in the basic IWP ditch and estuary prior to flowing into the IWP. ANL-W developed a neutralization model to supported the position that the IWP did not receive corrosive discharge of sulfuric acid. The results of studies to verify the ANL-W position led to a formal petition submitted to EPA Region X (via DOE) requesting reclassification of the IWP (Ref: Communication T. F. Gessel, DOE-ID, to K. D. Feigner, Region X EPA, "Reclassification of ANL-W Industrial Waste Pond", Sept. 10, 1987). As part of the closure plan for the IWP, samples of the IWP water and sediments were analyzed by Envirodyne Engineers, an EPA contract laboratory.

To characterize the hydrogeological properties beneath the pond and to demonstrate that ground water was not being contaminated by seepage into perched water zones, six boreholes were drilled (see Section H.2 of this Appendix H) to different depths around the pond at locations shown in Fig. H-1. Borehole ANL-M1 (54 ft) depth, M2 (80 ft) depth, M3 (60 ft) depth and M6 (423 ft) depth, were unsaturated (essentially dry) and ANL-M4 and M5 contained momentary pockets of water which self-drained after a few hours. Before the pockets of water percolated into the fractured basalt in ANL-M5, samples were taken and submitted to Envirodyne Engineering; only small samples were taken from M4 before it drained dry. Inorganic and organic analyses were performed on water sampled from borehole M5. Also, ANL-W Analytical Laboratory analyses of the water sampled from borehole M4 and M5 were compared with analyses from other ANL-W sources which confirmed that the source of seepage into M4 and M5 was from the IWP (Ref: ANL-W Communication from R. Villarreal to M. Holzemer, July 20, 1988.) The results of all analyses performed on the M4 and M5 water

showed that EP toxic elements were undetected or in concentrations lower than drinking water tolerances.

H.2 HYDROGEOLOGY OF AREA ADJACENT TO IWP*

H.2.1 Borehole Investigation Program

In order to characterize the hydrogeology adjacent to the industrial wastewater pond, ANL-W implemented a Borehole Investigation Program. The program was designed to fulfill the requirements as described in the RCRA Ground-Water Monitoring Technical Enforcement Guidance Document (1986). In order to meet these requirements the operator must collect sufficient information to: (1) identify and characterize the uppermost aquifer and potential contaminant pathways, and (2) support the placement of wells capable of determining the impact of the facility on the uppermost aquifer.

The initial conceptual approach was to drill three boreholes and complete the boreholes as monitoring wells (ANL-M1, ANL-M2, and ANL-M3, Fig. H-2). Two of the boreholes would be located down gradient of the industrial waste pond and a third borehole would be completed upgradient of the pond. The purpose of the down gradient wells was to assess the water quality potentially derived from the pond. The purpose of the up gradient would be to determine background or ambient groundwater quality. A triangular configuration was selected because it required the minimum number of holes necessary to comply with RCRA groundwater monitoring guidelines. Additionally, the hydraulic gradient could be determined utilizing three wells. Although the targeted sedimentary interbed was present in these three wells, groundwater was not encountered. The program was subsequently modified to include three additional boreholes (ANL-M4, ANL-M5 and ANL-M6).

The "first" or uppermost sedimentary interbed occurring at an approximate depth of 40 to 50 feet below the ground surface was designated as the target zone for evaluation. This interbed was selected because it was

* Ref: Northern, 1988

deemed that this would be the first unit that might perch water or be saturated, (B. Lewis, 1987). The borehole drilling plan was designed based on this premise.

H.2.2 Borehole Documentation

Detailed borehole logs describing the various lithologies encountered were recorded during drilling. In addition, the U.S. Geological Survey later logged the boreholes utilizing a suite of geophysical tools. The geophysical suite included a caliper log, natural gamma log, neutron log (neutron-gamma-neutron), and a gamma-gamma log.

The following discussion summarizes the results of the drilling and geophysical logging obtained from the borehole investigation program. Ancillary information pertaining to water-quality samples collected and well installation and completion procedures is included. Significant responses on the geophysical logs are also described.

H.2.3 Borehole ANL-M1

Drilling of the first borehole, ANL-M1, was initiated on 11 August 1987 and completed on September 1, 1987. The hole was cored with HXB (3.5-inch) wireline core to a total depth of 54.5 feet; seventeen core samples and two Shelby tube samples were collected from this borehole. The core and Shelby tube samples were submitted to the U.S. Geological Survey's INEL office for storage and future analyses. Standing water was not encountered and the borehole was determined to be dry.

The geophysical logs indicate that two sedimentary interbeds are intercalated with numerous basalt flows. The first interbed was encountered from approximately 26 to 30 feet and the second interbed occurs from 44 to 50 feet below the land surface. The relative intensities of the neutron log indicate that the second interbed probably has a higher moisture content than the first interbed, although both interbeds are partially water saturated. Correspondingly, the gamma-gamma log suggests that the second interbed is relatively denser than the first.

H.2.4 Borehole ANL-M2

Borehole ANL-M2 was started and completed on September 14, 1987. A static water level could not be measured and the well is considered dry.

The geophysical logs recorded in the borehole indicate that a single sedimentary interbed occurs from 40 to 47 feet below the ground surface and that although moisture is present, the unit is unsaturated. This corresponds closely to observations made during drilling. In comparison, the lower 4 feet of the surficial loess cover contains a higher percentage of moisture than the sedimentary interbed. The caliper log suggests that the basalt is highly fractured throughout the bottom 30 feet of the borehole.

H.2.5 Borehole ANL-M3

The drilling of borehole ANL-M3 was started and completed on September 15, 1987. The borehole was drilled to a total depth of 60.0 feet below the ground surface. The hole was probed and determined to be dry.

The geophysical logs indicate that numerous basalt interflows overlie a thin sedimentary interbed (4 feet thick) near the bottom of the borehole. In correlation with the lithologic log, the neutron log confirms the presence of moisture in the upper portion of the interbed. The relative moisture content declines with depth in the underlying highly fractured basalt unit. The fractures within the underlying basalt unit may be infilled with detrital sediment.

Similarly to borehole ANL-M2, the lower portion of the surficial loess cover contains a higher relative percentage of moisture than that contained in the sedimentary interbed.

H.2.6 Borehole ANL-M4

Borehole ANL-M4 was started on September 15, 1987 and completed on September 16, 1987. The total depth of the borehole is 68.0 feet. The borehole was then backfilled to 30 feet below ground surface and completed as

a monitoring well. A static water level has been consistently measured at about 28.5 feet below ground surface.

The geophysical logs recorded in the borehole indicate that numerous basalt flows dominate the subsurface geology. It is doubtful that the thin sedimentary interbed logged from 13 to 15 feet during drilling actually exists as evidenced by the lack of a response of the gamma and gamma-gamma logs. There may be some sediment infilling within this zone of fractured basalt.

Although a measurable water level was observed in this borehole, it is attributed to secondary permeability within the fractured basalt flows. Apparently, the water is following a pathway along large fractures or voids as evidenced by the pronounced responses on the caliper and gamma-gamma logs and the lack of response on the natural gamma log. This is further substantiated by both the caliper and the gamma-gamma logs which confirm the presence of large fractures or voids described on the lithologic log at approximately 30, 45, and 60 feet below the ground surface.

H.2.7 Borehole ANL-M5

The drilling of borehole ANL-M5 was started on September 17, 1987 and completed on September 18, 1987. The borehole was drilled to a total depth of 63.3 feet below the ground surface; surface casing was set to a depth of 6.8 feet. Because a sustained flow of water was encountered during drilling, the borehole was completed as a monitoring well. The static water level is approximately 58 feet below the ground surface.

The geophysical logs indicate that a series of basalt flows dominate the subsurface geology. There is no indication that a sedimentary interbed was encountered in this borehole. The zone of water seepage corresponds with a zone of fractured basalt as evidenced by the various logs. A water-quality sample was collected from this well for analysis of hazardous constituents listed in Appendix VIII (EPA Subpart D 261.33).

H.2.8 Borehole ANL-M6

The drilling of borehole ANL-M6 began on September 17, 1987 and was completed on November 14, 1987. The total depth of the borehole is 423 feet. A static water level was initially measured at depth of 62.5 feet below the ground surface prior to extending the borehole. After the borehole was drilled to 423 feet, there was insufficient water to obtain a static water level.

The geophysical logs indicate that numerous basalt flows dominate the lithologic sequence. No sedimentary interbeds were encountered in the upper portion of the borehole, although the gamma log gives some indication that two basalt fracture zones (46 to 51 feet and 59 to 64 feet below the ground surface, respectively) may be infilled with sedimentary detritus. A seven-foot thick sedimentary interbed is present from 407 feet to 414 feet below the ground surface. Two cinder zones (scoria) were also encountered in the borehole; the first from 262 to 267 feet and the second from approximately 284 to 294 feet below the ground surface. Responses on the neutron log imply that a number of zones are partially saturated.

H.3 SUBSURFACE CHARACTERIZATION*

One of the primary objectives of the borehole investigation was to characterize the geologic and hydrogeologic conditions below the industrial waste pond. The following inferences and conclusions were derived from the results of the Borehole Investigation Program.

H.3.1 Geology

Basaltic lava flows dominate the subsurface lithology with sedimentary interbeds and cinder zones intercalated between interflows.

* Ref: Northern, 1988

A fence diagram was constructed to display the lateral discontinuity of the various sedimentary interbeds underlying the pond. Boreholes ANL-M1, ANL-M2, ANL-M3, and ANL-M6 were selected because of their proximal location with the pond and they were considered to be representative of subsurface conditions.

The surficial loess deposit is present at all the boreholes, but to vary thicknesses. The loess cover is most prevalent at ANL-M2 and ANL-M3 where it is 10 feet and 8 feet thick, respectively. At ANL-M1 and ANL-M6 the loess deposit exists as a thin veneer overlying the basalt and is 0.5 feet and 2.0 feet thick, respectively.

A relatively uniform sequence of basalt interflows underlie the surficial loess deposits. This sequence is approximately 40 feet thick at boreholes ANL-M1 and ANL-M3, and about 30 feet thick in borehole ANL-M2 before the targeted sedimentary interbed is encountered. A thin sedimentary interbed was encountered from 26 to 30 feet in borehole ANL-M1 and from 41 to 44 feet in borehole ANL-M3 prior to penetrating the targeted zone. These thin deposits may have been slight depressions in the paleotopography which infilled between basalt flows. These two interbeds probably represent discontinuous loess stringers and are not correlative between boreholes.

The targeted sedimentary interbed is approximately 6.5 feet thick in borehole ANL-M1, 5.0 feet thick in ANL-M2, 4.0 feet thick in ANL-M3 and is absent in boreholes ANL-M4, ANL-M5 and ANL-M6. This deposit represents a significant hiatus during fissure-flow activity. The absence of the interbed in the vicinity west of the pond is attributed to the area having been a paleotopographic high during deposition of the unit and detrital material transported by wind or water was prevented from accumulating. The interbed is therefore correlative with the top of the underlying interflow.

An isopach map of the sedimentary interbed was developed to evaluate the lateral extent of the unit. Data points were derived from determining the thickness of the unit from available lithologic and geophysical logs within an approximate one mile radius of the ANL-W facility. Logs were utilized from the following drill holes and wells: DH-4 (Northern, 1981), DH-24 (Northern,

1975), DH-50 (Northern, 1975); EBR-II-2, USGS-100, Site 16, Arbor Test, Z1 (Dames & Moore, 1964), ANL-M1, ANL-M2, ANL-M3, ANL-M4, ANL-M5 and ANL-M6.

The maximum thickness of the sedimentary interbed is about 12 feet near the southeast corner of the facility. The interbed was not discerned in the following drill holes: DH-24, USGS-100, ANL-M4, ANL-M5 and ANL-M6. The sedimentary interbed is not consistently present in the vicinity of the Argonne National Laboratory facility as previously assumed. It appears that the sedimentary interbed is areally non-extensive east of the industrial waste pond and noticeable absent west of the pond.

H.3.2 Hydrogeology

A discussion of the occurrence and movement of water in the hydrostratigraphic units underlying and adjacent to the industrial waste pond is important in understanding the hydrogeologic system and evaluating the water bearing potential of these units. Lithologic characteristics and groundwater recharge, movement, storage and discharge are important components in the hydrogeological system.

A number of water-bearing units (both saturated and unsaturated) were distinguished from the Borehole Investigation Program. The following hydrostratigraphic units were identified and are discussed with regard to their water yielding capabilities. In descending order they include:

- 1) Recent surficial alluvium/loess deposits;
- 2) Quaternary basalt interflows of the Snake River Group;
- 3) Quaternary alluvium/eolian deposits between basalt flows (sedimentary interbeds);
- 4) Quaternary cinder zones (scoria) associated with eruptive volcanic events.

H.3.2.1 Recent Alluvium/Loess Deposits

Recent alluvium and/or loess deposits are composed predominantly of silt and fine sand; coarse sand or gravel was not observed in any of the borehole samples. The unit is moderately well sorted and uniformly graded. The thickness of the unit varies from 0.5 to 9.0 feet. These sedimentary deposits accumulated from a combination of overland flow during spring runoff and as wind transported detritus.

Moisture content generally increases with depth in the Recent alluvium and/or loess deposits. The unit is unsaturated, and hydrogeologically recognized as the vadose zone. Because the pressure in the unsaturated zone is negative, it is not capable of yielding water to a well and therefore cannot be considered an aquifer. Recharge to this unit is from snowmelt infiltration and possibly lateral seepage losses from the pond. This area of the Snake River Plain is an area of net evaporation; precipitation averages about 8.5 inches per year (approximately 30 percent as snowfall) and the evaporation rate is nearly 29 inches per year (Robertson and others, 1974). Rainfall infiltration is therefore an unlikely source of recharge.

H.3.2.2 Quaternary Basalt

The Quaternary basalt hydrostratigraphic unit consists of successive basalt lava flows. Individual flows are 10 to 100 feet thick and some can be traced laterally between boreholes. Water occurs in certain localized zones or areas, probably related to inflow boundaries. Basalt interflows have both high primary and secondary permeabilities. Flow features such as gas vesicles near the top of each flow, lava tubes, and collapse structures produce zones of high primary permeability if interconnected. High secondary permeability within the basalt is a result of the interconnected features of vertical fractures and joints formed during cooling.

Successive flows are occasionally separated by sedimentary interbeds or cinder zones. Sediment infilling of fractures and joints along the top of the flow can significantly reduce the effective permeability of the basalt.

Water was encountered in boreholes ANL-M4, ANL-M5 and ANL-M6 within the basalt hydrostratigraphic unit although a sedimentary interbed was not present as a confining layer. The saturation within the unit is attributed to vertical leakage from the industrial waste pond which follows large, interconnected voids and crevices or a fracture zone. The extent of the saturation appears to be limited to a localized area in the vicinity of boreholes ANL-M4, ANL-M5 and ANL-M6. Water levels between wells completed in the basalt vary considerably, supporting the hypothesis that saturation is related to interconnected vertical fractures and/or jointing.

H.3.2.3 Quaternary Alluvium/Loess (Sedimentary Interbeds)

Two distinct sedimentary interbeds were encountered with depth adjacent to the industrial waste pond, along with a number of thinner sedimentary lenses. The sedimentary interbeds are comprised of silt to fine sand material. The upper interbed generally occurs at depths of 30 to 40 feet below the ground surface and varies from 4 feet to 6 feet in thickness. The lower interbed was encountered at a depth of 407 feet and is 7 feet thick.

The fine grained nature of the interbeds impedes the vertical flow of water but the interbeds are neither sufficiently thick nor impermeable to confine water movement. The relative response of the nuclear logs (neutron and gamma-gamma) imply that there are not any perched zones overlying the sedimentary interbeds (Poeter, 1988). This hydrostratigraphic unit represents an aquitard under stress. The two interbeds may be partially saturated, but are not capable of yielding water and therefore cannot be considered a viable unconfined aquifer.

H.3.2.4 Quaternary Cinder Zones

Two cinder zones were encountered in borehole ANL-M6 from 260 feet to 272 feet and from 282 feet to 294 feet below the ground surface, respectively. Geophysical logs imply that both zones are partially saturated. Because the unit is not saturated, it is incapable of yielding water to a well. There was no indication of moisture above either cinder

zone. This unit does not demonstrate saturated conditions or act as a confining horizon and is therefore considered a portion of the vadose zone.

H.4 GROUNDWATER FLOW*

Groundwater flow is complex because of aquifer heterogeneity and the presence of multiple hydrostratigraphic units with either discontinuous or leaky connections.

Table H-3 displays static water level measurements obtained during the field investigation. A potentiometric map could not be constructed because of the lack of data points to evaluate a horizontal flow direction.

Water from the industrial waste pond moves in a westerly direction through fractures, joints and interconnected vesicles within the basalt. Although a westerly gradient is suggested by boreholes ANL-M4, ANL-M5 and ANL-M6, the predominant groundwater gradient is nearly vertical in the investigated area.

TABLE H-3
Water Level Elevations
(in feet above mean sea level)

DATE	ANL-M1	ANL-M2	ANL-M3	ANL-M4	ANL-M5	ANL-M6
21 Sept 1987	---	dry	dry	5095.74	5065.63	5059.53
22 Sept 1987	---	---	---	5091.49	5065.93	---
23 Sept 1987	dry	dry	dry	5090.04	5065.73	^a
09 Nov 1987	dry	dry	dry	5090.20	5065.61	^a
20 July 1988	dry	dry	dry	5090.19	5065.52	---

^aWater depth insufficient to measure a static water level.

* Ref: Northern, 1988

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